INTEGRATED EDITION OF THE PETROLEUM ENGINEER

the Petroleum Engineer

FOR MANAGEMENT

OCT 1960

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THE PETROLEUM Engineer

FOR MANAGEMENT

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Indexed by Applied Science and Technology Index, The Engineering Index, Inc. and Chemical Abstracts

The Petroleum Engineer for Management, published monthly, August through June, semi-monthly in July by The Petroleum Engineer Publishing Company, 800 Davis Building, Dallas 2, Texas. Subscription rate to the petroleum industry, United States, Canada, and foreign, $4.00 per year; $7.00 for 2 years; $9.00 for 3 years; $1.00 for single copy. Entered as second-class mail matter May 1, 1932, at the post office in Dallas, Texas, under the act of March 3, 1879.

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highlights *and footnotes of the news*

More than a trillion barrels of oil-in-place, a 250-year supply for U.S. at present consumption rate of more than 9,500,000 bbl per day is estimated in new information on extent and richness of most important oil-shale deposit in nation. Federal Geological Survey data indicates this extent for deposits in Piceance Creek Basin in Colorado portion of Green River formation.

No sale to Castro. More than 100 U.S. suppliers have refused to deal with a Cuban agency set up in Houston to buy parts for American oil refineries seized by the Cuban government.

Operating revenues of interstate natural gas pipeline companies are up, latest figures of the Federal Power Commission show. For the month of June revenues totaled $253,624,679, an increase of 14.9% over the previous June. For the 12-month period ending with June revenues were up even more. Including June of this year, revenues were $3,377,982,264, which was 17.6% greater than for the like period a year ago.

FPC has turned down a request to investigate natural gas reserves of the Green River Basin area of Wyoming. The request was made by the Green River Basin Corporation, which claims it has discovered the world's second largest natural gas reserves. FPC says it has no authority under the Natural Gas Act to make such an investigation, neither does it have power to direct pipeline companies to buy gas from Green River.

The Southwest's petrochemical industry will continue to grow rapidly for the next several years, and Texas and neighboring states can expect to keep on attracting the major share of the nation's petrochemical expansion, a report by the Federal Reserve Bank of Dallas predicts.

The Southwest had 43% of U. S. petrochemical plants already operating and 57% of those under construction in 1959. Most were in Texas and Louisiana.

OFF FOR THE GLOBAL OIL STORY . . . Ernestine Adams, Management Editor for The Petroleum Engineer, checks aboard KLM's Flight 684 at Houston, Texas, with Flight Steward H. W. van Voorthusen with next stop: Amsterdam, Holland. Miss Adams' extensive two-months' tour of the oil capitals of Europe will take her into nine countries with stops scheduled for The Hague and Amsterdam, London, Paris, Nice, Madrid, Brussels, Milan, Rome, Athens, Vienna, Dusseldorf and Hannover. Look for her factual on-the-spot reports of world petroleum activities and outlook in an early issue of PE.

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800 DAVIS BUILDING, DALLAS, TEXAS, CABLE ADDRESS: PEPUB

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Profit Possibilities in Personnel

Before me is a letter from an old and valued friend. It's typical of many we have received in recent months. Typical, also, I think, of the times.

It reads in part:

> "Dear Joe:
>
> "It will probably come as somewhat of a surprise to you to know that I am retiring as Vice President of my company.
>
> "As you are aware, I have had extremely broad experience in sales and management and a very wide acquaintance with engineers and executives of the oil companies throughout the United States, Canada, and South America. I am a registered professional engineer in Texas, and also a graduate of the Harvard Advanced Management School.
>
> "While the company has been very fine in their retirement plan, I naturally (being an old 'wheel-horse') don't want to sit by and twiddle my thumbs. The thought occurs to me that you or others of your organization might know of some concern that could utilize my broad acquaintance and knowledge of the industry."

Here is a relatively young man (age 58), with an outstanding industry record, of high moral character, who is a victim of circumstances. Obviously, the situation has been brought about by the many factors affecting our world-wide oil industry today. Nevertheless, it is not new to, nor confined to the oil industry.

With the advent of social security, pensions, and retirement plans, countless well-qualified people are being forced into early retirement. Is American business over-emphasizing the youth movement? Sure, new blood is important in any organization, yet I believe you will readily agree a mixture of seasoned "old pros" and young recruits make for a healthy organizational structure.

One of our great needs today is to utilize all our brainpower and "know-how" at all levels of business and government if the democratic philosophy is to survive against the onslaught of Mr. Khrushchev and company.

Now what can be done about this waste of experience and brainpower?

We feel sure some company can use the man who wrote this letter. If you are the one, please write us and we'll pass the word along. We'd like to get the men past 50 or 60 with a successful record in touch with companies that can use them. We'll be glad to offer our services as a clearing house to high caliber industry people in search of a new connection and to petroleum, equipment, supply and service companies in search of good men.

Write me personally and I'll do my best to help you get together.

Joe B. Hooker

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THE BEST SAFEGUARD IS KNOWLEDGE

In the oil and gas industry, knowledge is acquired only through long years of experience. Republic, as a pioneer oil bank in the South . . . with the South's largest Oil and Gas Department, has this knowledge. For decades, Republic has been pacing the industry, keeping thoroughly informed on new trends and developments, credit ratings, equipment distributors and all the varied factors involved in oil and gas financing.

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Course of Oil

Learn your economic ABC's

OUR NATION TODAY wages critical battles on several levels — most of them economic although usually disguised as politics. Unfortunately, we are a country of economic illiterates and we fight with blinders against the light of reality.

In world affairs Soviet leaders challenge us to a standard-of-living war. Our leaders respond with programs that move closer to Russian socialism. As one economist sees it, "For good or for ill, enterprise in this country is free in name only. Privilege means the privilege to be taxed and economic security is already a state function — and becoming more so."

Some of our politicians want us to take a "public prosperity" path, which the Soviet pursues. Are you puzzled about what that means? It means the state would spend more of the money you earn instead of you. Presumably this is for your good whether you like it or not.

On another level, we have some stiff competition with "Free World" nations. Western Europe and Japan are giving us a run for our effort right in our own country, largely because of wage differentials. European pay scales are one-half or less of the USA average rate; Japanese rates are one-fourth less.

And what is the answer to this of our political leaders? They seem to throw their weight to the competition: They want a higher wage scale (the minimum base increase would work right up to the top levels) and no decrease in taxes for business (either a rise in taxes to pay for more security or more deficient spending, which spells inflation and weakening of the dollar).

Western Europe learned soon after World War II the stagnation of socialism. It is pulling itself out of the sticky mire and its economic progress moves faster than that of the boasting Soviet. The Soviet has liberally borrowed the incentives of capitalism and the result has been a spur to industry. The USA, fascinated by the gadgetry of socialism, has developed a trend in the other direction and we are suffering with an anemic dynamism.

And where do we get the iron to cure us? We get it by relearning some economic fundamentals. First we should know that money not matched by productivity is only paper. President Roosevelt proved in his first seven years of office that money scattered at the consumer level by government does not make real jobs. He took over with 8 million unemployed (1931) and at the end of those seven years of "made work" 9½ million were unemployed. Boiled down, you don't get something for nothing.

If every U. S. citizen understood that first "iron pill" thoroughly, most of our economic and — as a by-product — our political problems would be solved. *Don't buy anything politically you're not willing to pay for economically.*

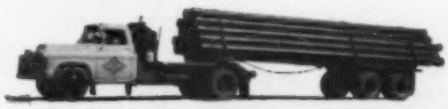
"Free medical care" for the elder citizens sounds good even though a trifle socialist. (We haven't talked to *one* oldster who wants it and we've asked many.) But what about "oil for all the people"? (A phrase from a politician's speech.) We know that's ridiculous. Free oil products, for instance, would cost the country much more than if consumers paid for what they got. First, we'd have chaos and then end up with rationed oil products.

For our economic iron, we must be more economically literate. Then use our knowledge to educate the political leaders we chose.

We vote in November to choose the heads of the most important nation for the free peoples of the world but that's not the end of our responsibility. As the most vital industry in our nation, we need also to educate our elected representatives by action, by speech, by letters, of the economic facts of life. Remember this, our economic war could well be more important than military struggles — and you are in it.

Ernestine Adams.

As delegate to a political convention, Joe Roughneck says he found out there's more to "rigging" than he'd thought. But on home ground, Old Pro Joe knows what to expect, when he's choosing supplies for oil well drilling. Joe demands Lone Star pipe because he knows he can depend upon its tough reliability. Made to API specifications, Lone Star casing, tubing and line pipe undergoes exacting quality control and multiple testing. It's conveniently available too. Made in the heart of the oil country, Lone Star pipe is deliverable overnight to 75% of Mid-Continent producers.



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petroleum profile

WHEN PAUL ENDACOTT, president of Phillips Petroleum Company, joined the company in 1923, he wasted no time getting his feet into the oil business. Three days after starting work as a newly-graduated engineer from the University of Kansas, Endacott was on the job in the rugged Osage country of Oklahoma where the oil boom was reaching full momentum.

His next few years were spent in the field, moving from oil boom to oil boom, from the Osage to the Texas Panhandle, surveying leases, staking drilling locations, and supervising the construction of natural gasoline plants, pipelines, and the many other facilities which Phillips added during that early period of its rapid growth.

Today, when Endacott turns on the gas in his ranch home in the bluestem country northwest of Bartlesville, he is well acquainted with what comes out of the jet. This acquaintanceship began intimately in 1927, when he was assigned to the Philgas division, at that time the company's liquefied

petroleum gas organization in Detroit, Michigan. That was the same year Phillips began retail marketing of its own products.

While in the Philgas division, Endacott originated and developed the tank truck method of distributing LP-Gas to homes and the small-cylinder "Self Service" system, both of which methods are now in common use. He assigned 20 patents to Phillips dealing with utilization and marketing of LP-Gas back in the days when LP-Gases were being wasted because of lack of markets and marketing methods. Today, Phillips is the largest producer-marketer of LP-Gases.

After seven years on his Philgas assignment, Endacott returned to Bartlesville in 1934 as director of sales research. Three years later, he organized the company's employee relations department and started *Philnews,* the company employee publication.

In 1938, Endacott assumed his first position on the executive staff when K. S. Adams was elected executive vice president and Endacott was named assistant to Adams. When the latter was elected president of Phillips, four months later, Endacott moved up to assistant to the president. He also served as chairman of the operating committee.

He was elected a vice president in 1943 and later the same year he was made a director and a member of the executive committee. Six years later, he was advanced to executive vice president and in 1951 he was elected president to succeed Adams who became chairman of the board.

The faith in Phillips management reaches far into the field, where a veteran gasoline plant superintendent recently pointed out that "the rapid skyrocketing of the company parallels the lives of two young engineering hands who were in bunkhouse number 2 at Borger, Texas, in 1926 while I was in bunkhouse number 3. They were Paul Endacott and Stanley Learned." Learned is now chairman of the executive committee and assistant to the president.

Near Borger, which at that time was just a spot in the Texas Panhandle, Phillips now has the world's largest natural gas liquids processing center, as well as a large refinery, butadiene plant, synthetic rubber plant, multi-purpose chemical plants and also the free world's largest carbon black plant.

In commenting on Borger's 33rd anniversary in 1959, Endacott disclosed a part he played in the founding of the city:

"How well I remember that day back in 1926 that Mr. Borger approached me at a nearby field construction job. He wanted to borrow for a few days a team of mules and small road grader to edge the streets of his newly staked-out prairie townsite preparatory to the auctioning of lots."

Endacott, who was the collegiate basketball player of the year in 1923, has often emphasized that he didn't join Phillips to play on the company's basketball team which had been formed a few years earlier by Adams, then a young warehouse worker. However, it came to pass that Endacott did play on the team in the mid-20's. He is still in Helms

PAUL ENDACOTT

President

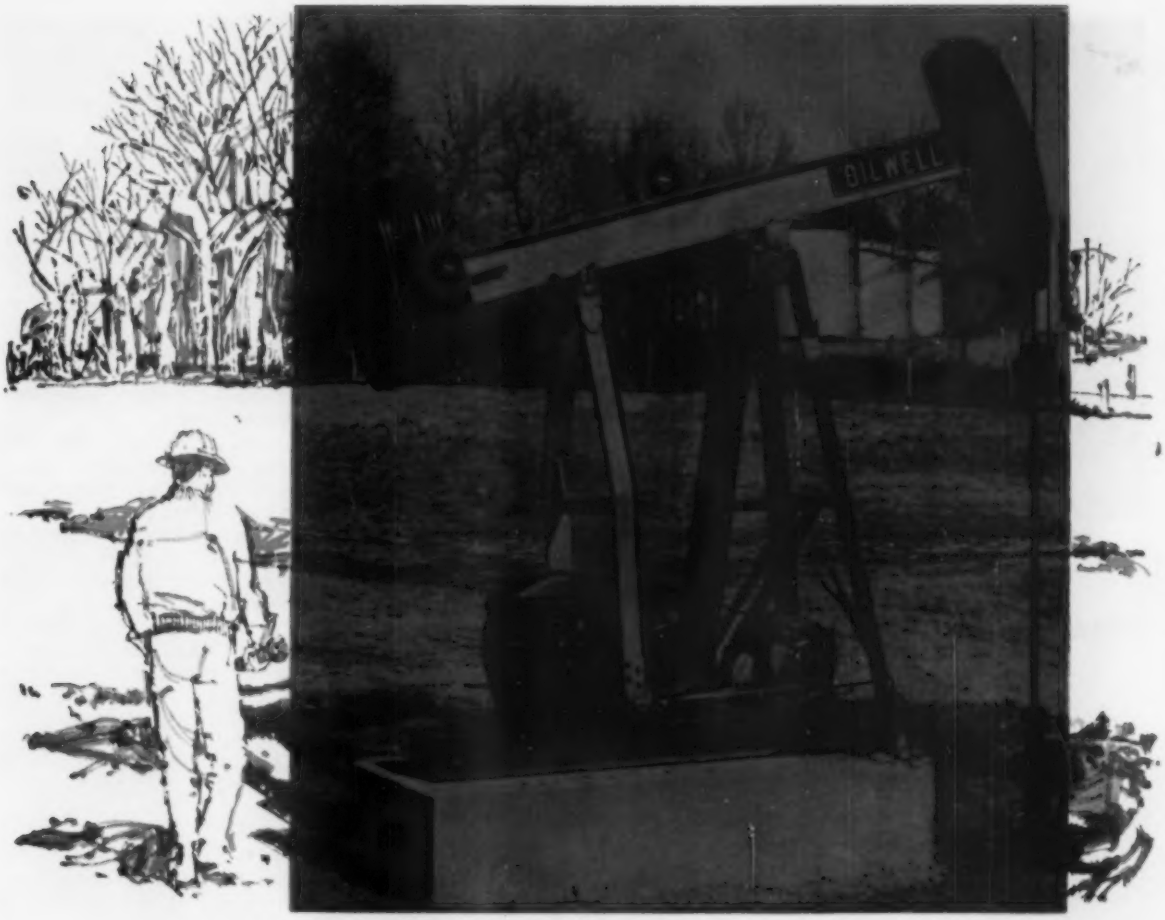
Phillips Petroleum Company

Foundation's basketball hall of fame as an all-time All-American.

He is a native of Kansas, having been born and reared in Lawrence. Since the University of Kansas is located at Lawrence, he received his entire education there on the banks of the Kaw. While at the University, Endacott was selected for membership in Sigma Xi, honorary scientific society, and Tau Beta Pi and Theta Tau, professional engineering fraternities. He was the first recipient of the school's honor award in 1924. He has served as president of the University alumni association and in 1948 received its distinguished alumni service citation.

Endacott is a director of the First National Bank in Bartlesville and the Bartlesville chamber of commerce; the chairman and trustee of Frank Phillips Foundation, Inc., a charitable organization, and a member of the board of trustees of the University of Kansas endowment fund. He is a director of the American Petroleum Institute and a member of the National Petroleum Council and of several important oil and gas industry committees. His industry affiliations also include Independent Natural Gas Association of America, Mid-Continent Oil and Gas Association, and the 25-Year Club of the Petroleum Industry.

He and his wife, the former Lucille Easter of Bartlesville, live in Bartlesville but spend as much time as they can at their D-Bar-D ranch (named for their two sons, Don and Dick). Don, the older son, is now an attorney in Lincoln, Nebraska, having graduated from the University of Kansas and Harvard University Law School. Dick, a 1960 graduate of the University of Kansas, is going to Yale University Law School.



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Small size—big output . . . "Oilwell" 25L3 Pumping Unit

This modern unit has a *long stroke* that gets large volume with a lighter beam load. You can use rod-type pumps and get the same number of barrels as from tubing pumps using equal horsepower. Round trips are cheaper because only rods have to be pulled and not tubing.

"Oilwell" 25L3 units can be furnished with an internal combustion engine drive, or with an electric motor drive directly beneath the samson post, as shown. Effective counterbalancing is provided by inexpensive slab-type weights on the extended end of the walking beam. Adjustment is easy and sure. Why not get the full story from the nearest "Oilwell" store?

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Export Office—30 Rockefeller Plaza, New York 20, N. Y.

the conference table

Science Takes Faith

Dr. Wilder Penfield, Canadian neurologist and neurosurgeon says: "Science casts no light on the nature of the mind or spirit. Perhaps it never will. Materialism is not scientific. It is a matter of faith, too; a kind of religion to which many cling in ignorance."

Now "Autoscrip"

Union Oil Company stations are now issuing "76 Autoscrip" which may be used as cash for purchases. 76 Autoscrip comes in pads, similar to checkbooks. Each "check" is worth $1. The booklets are available in $5, $10, and $20 denominations. You may pay cash or charge it to your credit card account. The 76 Autoscrip is a convenient gift and allows those without a credit card a means of recording expenditures. It is suggested as useful for controlling purchases by younger members of the family.

Business Terms In Many Languages

For only 20¢ the U. S. Department of Commerce has put out booklets containing "Selected United States Marketing Terms and Definitions" in English and several other languages. We have the Spanish/English, French/English and Italian/English. There is an index and a number of idioms for business language. Samples are: "Gross national product," "net income," "markup," "depth interview," etc.

No Freedom Discount House

There's no bargain counter with freedom marked down. The Congo has taught us that if nothing else has. Independence is the Golden Fleece and only heros by their own effort can attain it. You can inherit freedom as we have from heroic forefathers but it is easily lost or frittered away. Nobody can give you liberty — nobody can buy it.

If you have it, you guard it with your intelligence, your devotion, your life. This is your most vital possession.

"Man thinks, therefore he is free," says the philosopher but today some states tell men what to think. Even in our country we have powerful voices directing man's thinking into patterns of economic slavery. And there are those who say it is better to live under communism than risk a devastating war.

Then what is freedom that it is so precious? Why should we work and read and struggle and die to hold it? Is it only because of the smell of decadence and human sacrifice in a community run for the state?

NO. In part, the slavery of men reminds us of the delight of freedom but there are more positive ingredients. Individual liberty to live one's life with private goals is the giant pep-pill of the ages. Without it we are forever in convalescense.

It is almost amusing to see Russia — ambitious and brainy — ape our methods of freedom within its slavery state. Even in this limited form of payment for initiative and intelligence, the ways of freedom bestow largess.

But the ways of freedom are not enough. Man must himself possess them. He must be able to decide, "I'll go to Iowa and work in the corn fields," or "I'll put my money in a store in Arizona and take my family there."

If the state tells him where to go and what to do, will he not remain a child forever?

The most powerful bomb ever unfused in economics was the release of individuals to seek fortune on their own. Every nation in the world copies our dividends of freedom of thought and effort. Every time we curtail this freedom we pour gray mediocracy into the burning white crucible of man's liberty of development. We've been seeped with socialist, statist programs until the glow of freedom has been dimmed. The way back is tough and the grayer the atmosphere the tougher it gets. Are you bold enough to take a flyer on freedom?

Analysis of Soviet Economy

A comprehensive picture of the Soviet economic situation has been compiled by the economic division of Lionel D. Edie & Company, Inc. Although brief this study is replete with data and covers much of the petroleum industry in which our readers are interested. As we understand this the 60-page booklets not including tables and the appendix are free upon request to the company at 530 Fifth Avenue, New York 36, New York.

✔ *Coercive power is inherent to a greater or lesser degree in all economic power, but its exercise is unlawful for all forms except labor monopolies — G. Warren Nutter, Economics Professor, University of Virginia.*

Advise or Decide

"The Personnel Function: A Progress Report" is one of the American Management Association's management reports (No. 35) in which each of the 17 chapters is written by a high company executive concerned with personnel. There are some excellent short essays on the increasing complexity of business needs, evaluation of jobs, labor relations, communications, etc.

One chapter tackles the definition of the terms "line" and "staff." Rarely do you find agreement on the meaning of these words. The Director of Employee Relations of General Dynamics resolves: "Classically, the staff shall advise and the line shall decide. The staff must brief the line and the line must make the decision." The author quotes Ernest Dale in listing five means by which the staff may exercise command powers over line executives (Research Report 20).

1. Command through superior articulation. Command may be achieved by the "man who can, through skill in

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Lufkin Chrome Clad Anchor Tape (above, right) is available with easy-to-read markings in feet, tenths and hundredths, in genuine-leather, hand-stitched case. The handiest thing you can carry, on job after job.

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SAGINAW, MICHIGAN

persuading others, bring about acceptance of his decisions."

2. Command through technical competence. The staff makes the decisions because it has technical skills and knowledge not possessed by the line.

3. Command through status. The staff specialist who is a member of the board of directors and vice president is not taken lightly at the divisional level.

4. Command through sanctions. "Staff sanctions," Dale observes, "may be so influential as to lead to demotion and removal of opponents."

5. Command by default. This, quite briefly, is the making of decisions by staff in situations where the line has taken no action.

This type organization structure is being eroded in the petroleum industry where operating management is on the staff side but it makes decisions on every level of the operating department all the way up to the vice president (of production, for instance. So we provide another opening for confusion between the two terms. Several companies have set up line-and-staff pairs. That is, the decision-maker and his adviser are at equal positions in status and in salary. In such an organization it would probably be difficult to discover who made the decisions.

Words

- *Five most important words — I am proud of you.*
- *Four most important words — What is your opinion?*
- *Three most important words — If you please.*
- *Two most important words — Thank you.*
- *Least important word — I.*

The measure of success is not whether you have a tough problem to deal with, but whether it is the same problem you had last year.

It takes struggles in life to make strength. It takes singleness of purpose to reach an objective.

The more extensive our knowledge of what has been done, the greater will be our power of knowing what to do.

The Year 1975

The U. S. economy will nearly double in a little less than 20 years, according to economists at Arthur D. Little, Inc., research firm. By 1975, gross national product will hit a record $835 billion, based on a projection from 1930. Total population of the U. S. will be an estimated 235 million; the labor force will total 94 million — an increase of 23 million wage earners. The average work week will be cut to around 35½ hours, but productivity (which has shown a gain of about 2½ percent annually since 1930) will soar to a record of $5.14 per man hour (vs $3.29 per hour in 1957). Power requirements to meet higher living standards will exceed 2,100 billion kwh (compared to 600 billion in 1957).

Guess What's Growing

Uncle Sam has just announced that he picked up approximately 2 million acres of the world's land between fiscal '58 and '59, Tax Foundation, Inc. notes. At the end of '58, the Federal government owned 769.7 million acres of land worth (with buildings) $45.6 billion. At the end of '59, 771.7 million acres of land (world-wide) and structures on it were valued at $49.2 billion.

Rising Costs of Super Highway System

With only one-third of the nation's ambitious $40 billion interstate highway building program completed, complaints of waste and poor planning are pouring into the special subcommittee of the House Committee on Public Roads. Disputes have arisen over routes chosen for the superhighways; high prices have been paid for right-of-way property; excessive use of expensive consulting engineers has been charged. One major fiasco was the construction of bridges and overpasses two feet too low for the truck-mounted Atlas missile to clear. Raising already completed structures and building new ones two feet higher will add about a billion dollars to the cost of the program.

Congressional investigators are busy sifting through charges of other expensive mistakes that may slow completion of the 41,000-mile network of highways far beyond the target date — 1972. Among them:

In little over a year, a bridge approach on one highway section has sunk 12 feet. Estimated cost of reconstruction: one million dollars.

If built, a dam proposed by a Federal agency would promptly flood a $10 million portion of a newly constructed highway section.

Last year, motorists were hit with an increase costing them an additional $500 million a year in gasoline taxes — which provide the major share of funds for the highway projcet. Now, the Administration is asking for another half-a-cent-a-gallon tax hike, a proposal that would place an added unfair burden on motorists. One reason: only two-thirds of last year's special taxes collected on motorists went into the highway trust fund. The other third (probably adequate to finance the road program deficit, if costs were kept in line) was sidetracked into the U. S. Treasury's general fund.

From *The Texaco Star*

Advertising Expenditures Increase

The 100 leading national advertisers, including seven oil companies, increased their advertising expenditures 9% to $2.5 billion in 1959, up from $2.3 billion in 1958, according to Advertising Age. Here are the seven and how much they spent:

Company	*1958*	*1959*	*% of sales*
Standard Oil Co. (New Jersey)	$22,998,300	$23,236,000	0.3
Standard Oil Co. (Indiana)	19,000,000	20,500,000	1
Texaco Inc.	18,186,095	18,500,000	0.7
Shell Oil Co.	16,241,130	15,270,000	0.8
Mobil Oil Co.	11,746,000	12,010,000	0.3
Gulf Oil Co.	12,150,000	10,170,000	0.3
Sinclair Oil Co.	5,661,200	4,900,000	0.4

The combined expenditure of the seven oil companies was $104,586,000, down from $109,461,231 in 1958.

Business, Ballots and Bureaus

A comprehensive indictment of the socialist trend in government was given early this year by Ronald Reagan, the movie and TV (General Electric Theatre) actor, at an employee information seminar of Shell Oil Company. We've only recently read it and we heartily recommend it to every citizen.

As he says we've been told for many years that any time the total tax burden passes 25%, free economy is in danger. Today 31¢ out of every dollar earned in the United States is paid in taxes, two-thirds of the 31¢ going to federal government. Ronald Reagan tells of taxes, of communist infiltration, of government socialistic projects, and suggests what we should do if we intend to stay a free nation.

Shell Oil Company will send you a copy of the address if you write 1008 West 6th Street, Los Angeles 54, California, and ask for "Business, Ballots & Bureaus" by Ronald Reagan.

Good Wells Make Good News

October, 1959

Recent Profit-Building Treatments with Fracturing and Abrasijet

The use of Abrasijet* — Dowell's abrasive jetting service — before fracturing often improves results of the treatment. Sometimes, it may even eliminate the need for fracturing. Here are four recent treatments in which Abrasijet helped operators improve profits.

- **Jack County, North Texas** (Three Old Oil Wells) These wells had been completed open hole in an 11-foot section of the Buttram sand at about 2600 feet. Previous fracture treatments had broken into water. Dowell engineers cut circular notches in the oil pay with Abrasijet to induce horizontal fractures. Each well was then fractured using 1000 gallons refined oil and 1000 pounds 20-40 mesh sand. Production from the three wells was increased 90 bopd with no water.

- **Kern County, California** (New Oil Well) This well was completed in the Vedder sand between 11,884 and 11,980 feet. Standard method of completion in this field had been to run a drill stem test, then sidetrack and recomplete with oil-base mud at a cost of $50,000 to $65,000. Dowell recommended Abrasijet and Waterfrac instead of sidetracking. Four circular notches were cut using Abrasijet. Waterfrac, using 30,000 pounds gelled water and 3500 pounds 8-12 mesh walnut shells (instead of sand), followed each notching. Production after treatment was 300 bopd instead of 100 bopd normally expected after conventional completion. Cost saving was over $10,000.

- **Eddy County, New Mexico** (New Oil Well) This well was to be completed into the very tight Premier sand. Operator needed a completion that would initiate a fracture and lower the breakdown pressure. Dowell used Abrasijet to cut slots at four levels between 3200 and 3225 feet. Lease oil, carrying one pound sand per gallon, was used to jet each level for thirty minutes. Well was then fractured using 12,000 gallons refined oil and 45,000 pounds sand. Treatment was down 3" EUE tubing, 10 bpm at 5000 psi. Well tested 364 bopd after treatment.

- **Burke County, North Dakota** (New Oil Well) This slim-hole completion was into the Madison lime at about 6100 feet. Operator wanted to use Abrasijet to cut a single notch to induce horizontal fracturing and avoid breaking into water. He did not want to cut the string completely, however, because a bottom-hole pump was scheduled. A single 180-degree notch was cut. After swab testing, the well came in flowing without further treatment. Most other wells in the area required fracturing and pumping.

The chances are good that your Dowell engineer can tailor treatments for your wells to improve production and reduce costs. Dowell services and products are offered from more than 150 offices and stations in the United States, Canada, Venezuela, Argentina, and Germany. Dowell, Tulsa 1, Oklahoma.

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Services for the oil industry DOWELL

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RCA Industrial Electronic Control is industrial dynamism of a higher order—a new electronic control of production operations resulting in a smoother flow through the plant, a bigger yield, and a degree of efficiency never before attainable.

Systems capabilities range from simple automatic monitoring to complete real-time control of a complex automated operation spread over a wide area. There are *now* three RCA Industrial Electronic Control Systems available:

The RCA-110 Industrial Control Computer System—Specifically designed for industrial applications to provide around-the-clock operating reliability, highest arithmetical speed and lowest cost installation. Solid state design, core and random access drum memory. Computer built for industrial environment.

The RCA-130 Industrial Data Transmission Link—Removes the limitation of distance in an automatic monitoring or control system. Provides reliable on-line, real-time transmission of analog or digital information via wire or radio, one-way or two-way. 100% checked.

The RCA-150 Industrial Data Analysis and Recording System—Provides high-speed, automatic monitoring and analysis of process and production status—plus computational capability for summarizing, averaging, totalizing and linearizing.

These new RCA systems incorporate industrial thinking as advanced as the electronic design of the equipment itself. The new concepts may well be of paramount importance to the future of your business. RCA Industrial Electronic Control Systems are available with Foxboro and other instrumentation.

For special industrial control problems, **Custom Systems** can be supplied to fit your exact needs.

To tell you how this modern kind of industrial automation works and the many things it will do, would fill a book. You will want to get the full story in person. Ask your nearest Foxboro representative or write—Industrial Computer Systems Department, Electronic Data Processing Division, Radio Corporation of America, 21 Strathmore Road, Natick, Mass.

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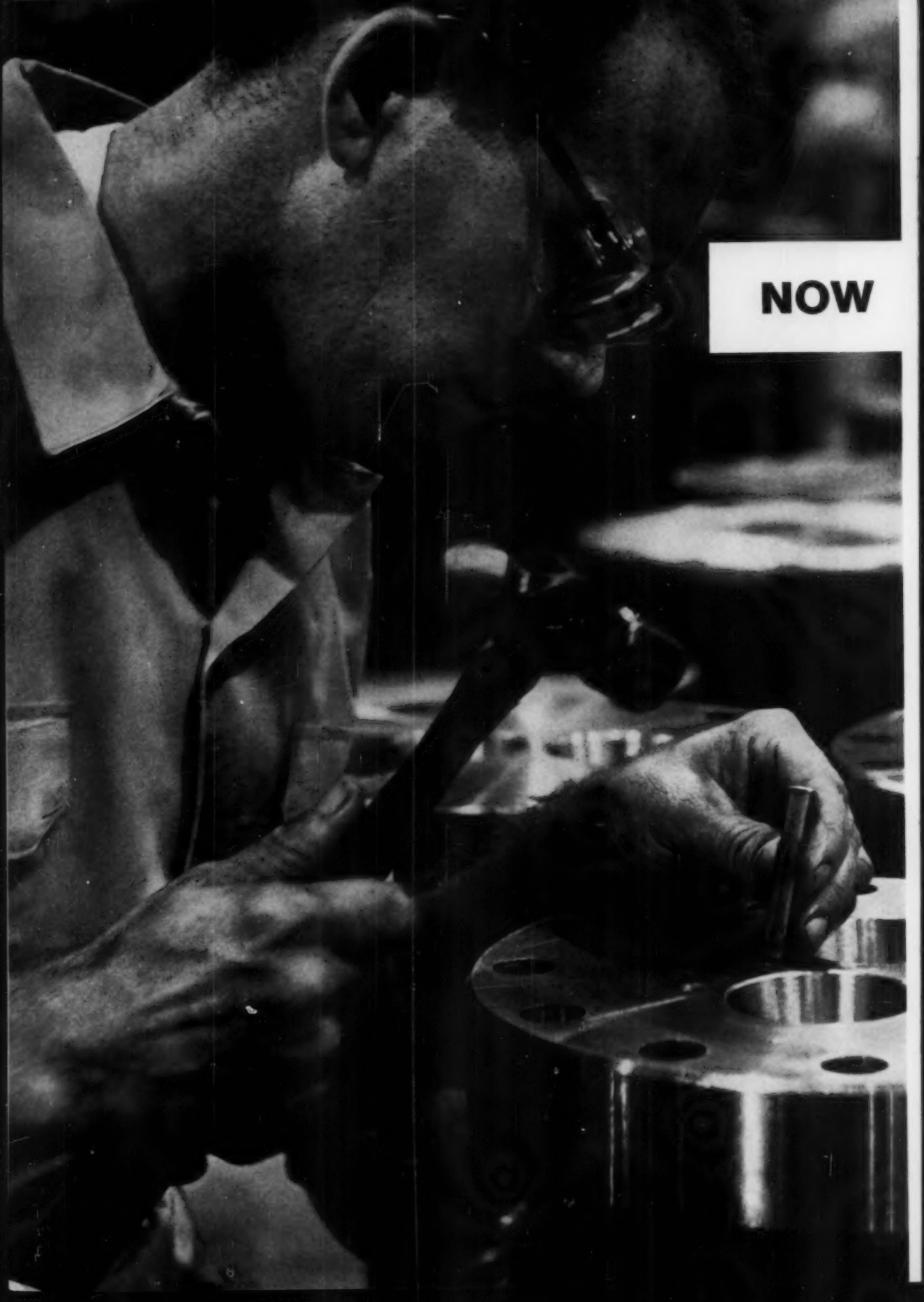
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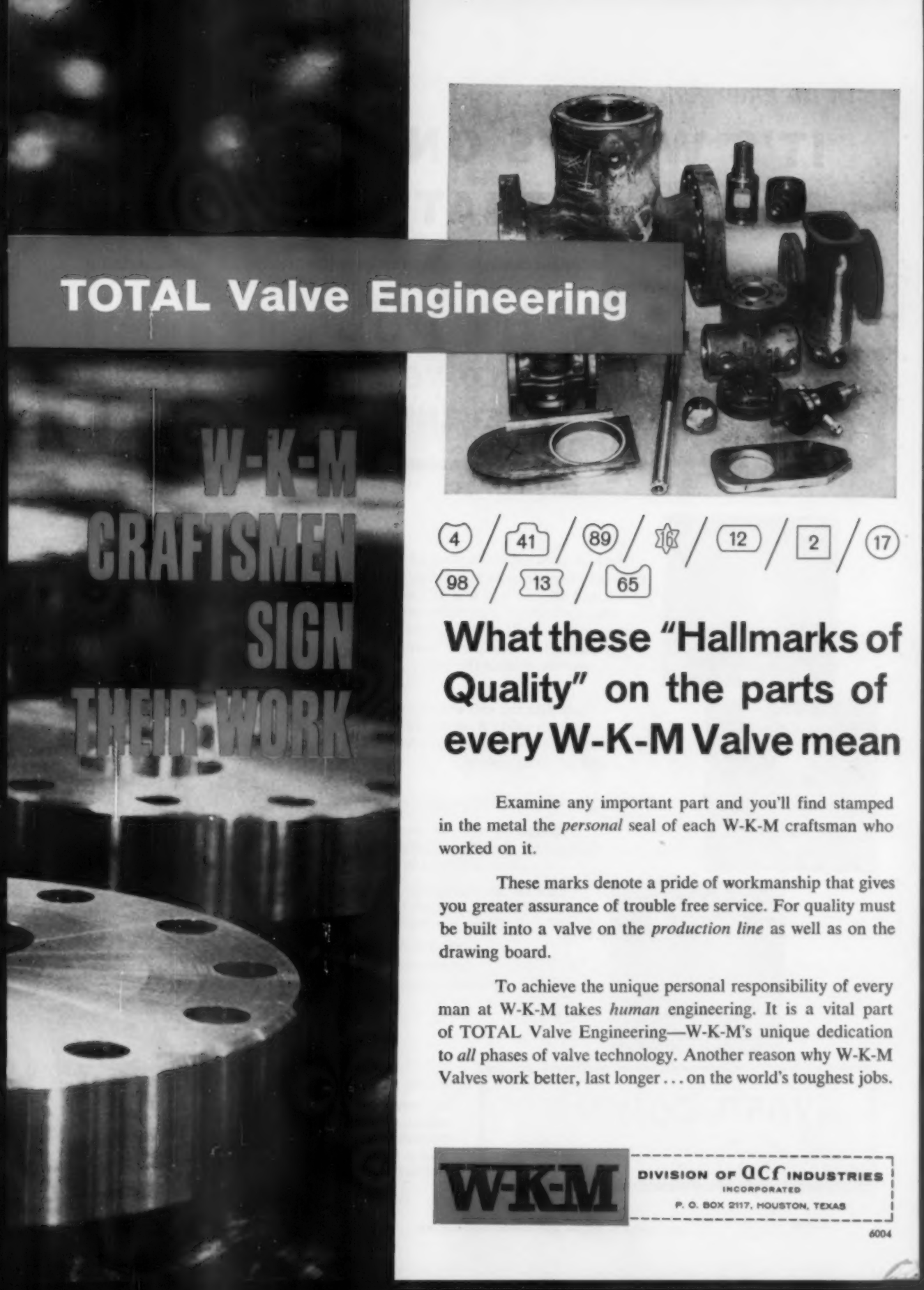

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Examine any important part and you'll find stamped in the metal the *personal* seal of each W-K-M craftsman who worked on it.

These marks denote a pride of workmanship that gives you greater assurance of trouble free service. For quality must be built into a valve on the *production line* as well as on the drawing board.

To achieve the unique personal responsibility of every man at W-K-M takes *human* engineering. It is a vital part of TOTAL Valve Engineering—W-K-M's unique dedication to *all* phases of valve technology. Another reason why W-K-M Valves work better, last longer . . . on the world's toughest jobs.

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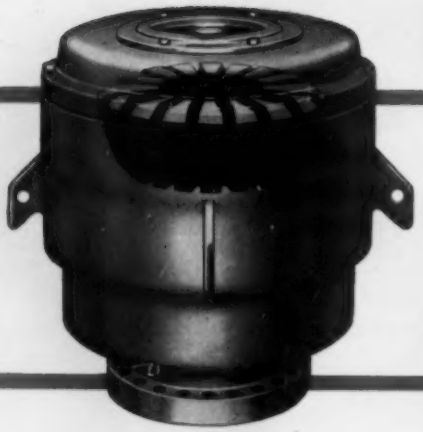
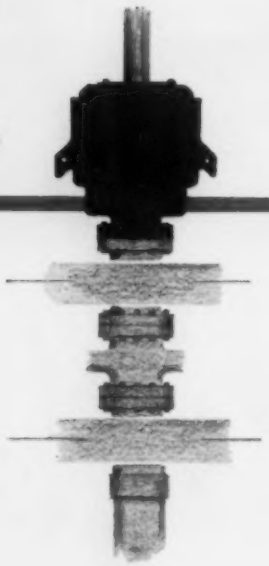
in an emergency...

IT'S WHAT'S ON TOP THAT COUNTS!



HYDRIL
BLOWOUT PREVENTERS



And when "what's on top" is a Hydril Blowout Preventer, you *know* you can shut off your well in a jiffy when the need arises... no matter what member of the drill string is in the preventer... no matter if there is *nothing at all in the hole!*

Then, with the well securely shut in, you can safely go about the business of correcting the trouble and regaining control.

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THE FAMOUS "GK": for most wells, deep holes, high pressures... proved by more than 15 years' experience in every oilfield in the world!

SUPER "GK-10,000": for deepest drilling and highest pressures... here's the renowned "GK" beefed up for the toughest jobs!

"MSP-2000": for low-pressure wells... for remedial and workover jobs... this lighter weight "GK" type preventer provides an extra margin of safety.

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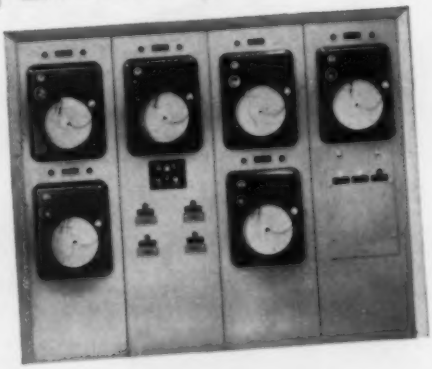

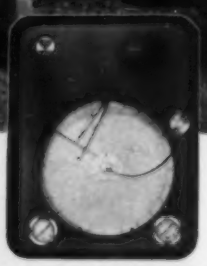

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MANAGEMENT PROBLEMS ABROAD TAKE SPECIAL SOLVING

An experienced executive gives a broad outline of what you may encounter in overseas operations and provides some rules to go by.

H. W. HAIGHT

NOT LONG AGO I attended a management meeting which spent two full days discussing only one problem peculiar to overseas operations and wound up the meeting with the problem still unresolved. So you see management does have some overseas problems for which no quick and easy solution is readily apparent.

In searching for a solution to his problem the overseas manager may, in general, use the same basic approach that he would use at home. He will collect and carefully analyze all the facts bearing on his problem. He will get all the advice available from associates and others. He will develop and evaluate alternate solutions, and finally he will reach a decision on what he believes is the proper solution.

Implementation of his decision is quite another matter. It may be simply a matter of issuing a notice or order, or if his decision has an important effect on others, he may decide to discuss it with those affected and explain the reasons for his decision.

In other cases, the settlement may require protracted negotiations with others, during which he may be forced to modify or compromise his proposed solution. In still others, he may have to revert to the courts or to arbitration.

Regardless of how the overseas manager goes about solving his problems, if he is to be successful, it is essential that his decisions be based upon a thorough knowledge of the history, the political, economic, and social conditions, and upon the philosophies of the country in which he is operating.

Early Field Development Problems

Geologists, like the old gold prospectors, believe that oil is where you find it, and for some reason they always find the best fields in remote, isolated, uninhabited areas. Outside of North America they seem to prefer dense jungles and inhospitable deserts where no one wants to live. This bias on the part of geologists, creates many problems for management.

Once a field has been found the field manager inherits the job of recruiting the people necessary to develop and produce it. His first efforts will be directed toward trying to recruit local people. In some countries he will be able to find unskilled and skilled labor, clerks, doctors, lawyers, civil engineers, drillers, geologists and some supervisory and management people, and will have to bring in only a limited number of foreign personnel to get his enterprise going.

In others, he may find almost nothing except a few unskilled laborers and will have to bring in substantially all of his personnel from outside. He will need all the usual operating and staff people, but in addition he will need perhaps 20 to 30 percent more people to take care of the others.

Before the field manager can assemble all the people he will need to develop and produce his oil field, he will generally find that he will need all the facilities of a small city. His first job is to establish means of communications with some supply source so that he can bring in materials and supplies on a regular basis. This will usually take the form of building good roads and airstrips. And, since most or all of his material may have to be imported, he will need access to a seaport. If it does not exist, he must build one.

As soon as he has evidence that his oil field is a good one, he will begin to plan for and construct the permanent facilities required to develop the field fully and to operate it during its producing life. It will have to be done in stages as his operation grows.

In order to get and keep the people he needs, he will have to construct comfortable housing, develop good water supplies, install sewer and telephone systems, build power plants and distribution systems, build stores and arrange for regular supplies of food, and perhaps clothing and other necessities. He will need shops and warehouses to make repairs on equipment and take care of large stocks of material. Then he will need hospitals and clinics to take care of the sick and injured; schools to educate the children of employees; and finally, he will have to provide recreation centers and churches to keep people reasonably happy.

Eventually, if all goes well, he will get his oil field, and perhaps others, on a commercial basis and then problems of a different nature will arise.

Headquarters Problems

In most countries of the world the minerals, including oil and gas, belong to the nation. Governments of many countries have deemed it advisable to have their petroleum resources developed by private capital, sometimes through enactment of favorable petroleum legislation and sometimes by means of negotiated contracts. Some countries do not allow private enterprise to participate in the oil business.

Fortunately for the well being of the people of the free world, the trend has been for more countries to favor private development of their petroleum rather than less.

Tremendous amounts of capital required for development of petroleum resources has led to large foreign investment in some countries. The capital has been provided principally by American, British, Dutch, and French companies.

Since it is necessary for these companies to deal with governments which administer petroleum laws and policies, they generally establish headquarters offices in the capitals of the countries in which they are operating. These offices are usually established before the geologist discovers his first oil field.

Top management of the headquarters offices will become involved in a host of problems with the government and the public, but its first and most important responsibility, if it is to stay in business and make a fair return on the company's investment, will be to establish a sense of partnership,

mutuality of interest, and fair dealing between the company, the government and the public at large.

It must develop and implement policies which will result in its being regarded as a good corporate citizen of the host country and convince the people that it intends to work for the best interests of the country as well as the owners of the company. This will call for policies which may include:

1. Strict compliance with the laws of the host country.
2. Adaptation to the local customs and objectives.
3. Nonintervention by foreign employees in the political affairs of the host country.
4. Maximum use of the language of the host country.
5. Employment and training of citizens of the country to occupy positions throughout the company up to and including top management, on a basis of merit.
6. Treatment of local people by foreign employees to be based on dignity and respect.
7. Nondiscrimination in personnel policies and compensation between local and foreign employees.
8. Participation in community affairs at all levels.
9. Contributions to charities and education consistent with size and position of the company.
10. Supply host country with good quality oil products at reasonable prices before entering export markets.
11. Encourage development of local industry and agriculture on an efficient basis.
12. Purchase of products produced in the host country, after careful consideration of price and quality.
13. Use of local banks and insurance companies.
14. Participation in cultural affairs.
15. Adoption of a reasonable and courteous attitude in discussions and negotiations with governmental officials, and when there is reasonable doubt give the benefit of doubt to the government.
16. Integrate the company into the host country.
17. Communicate to the government and public the objectives, policies and problems of the company to the extent possible.
18. Strict avoidance of bribery.

Instability of Governments

Relative instability of governments and government officials, and violent changes by revolution, present many problems to overseas management.

In all countries there is opposition to the existing regime. The degree and strength of the opposition varies from country to country. The oil industry overseas is nearly always a target of the opposition, and the regime in power is frequently accused of "selling out" or "giving away" the wealth of the country to foreigners. These and other accusations often cause government officials to put pressure on management to modify contracts and agreements in favor of the government.

Some other problems of overseas management are:

1. Government controlled prices for petroleum products below cost of production.
2. Demands that the oil be refined in the producing country.
3. Demands that the oil be refined in the consuming country.
4. Demands that exported oil be transported in tankers of the producing country.
5. Demands that the governments in the producing country participate in the profits, but not the losses, derived from transporting oil from and refining and marketing in consuming countries.
6. Demands for international proration of production to raise prices.

Problems of Nationalism and Communism

The most serious problem facing oil industry management in many countries overseas today is the growth of communism and extreme nationalism.

Shrinking of the world by rapid transportation and communications, the growth of foreign trade, and increased travel and education have shown many people in the lesser developed and immature countries that their standard of living in comparison with more mature and highly developed nations, such as the United States, leaves much to be desired. They have seen and heard what is taking place, and they have developed a burning desire to have the same things that other nations have — and they want them quickly.

Their leaders, and particularly the younger ones, are impatient and are not satisfied to wait for future generations to obtain them. They want their "Rome built in a day" and feel frustrated that they don't already have it.

These frustrations seem to have the psychological effect of developing an inferiority complex which causes the younger leaders to think that they, and not foreigners, have the supreme responsibility for improving the lot of their people. They have complete confidence in their ability to do the job and their political philosophy is generally based upon the idea that the state should provide capital.

Whether in power or out these people are the leaders of the cult of extreme or destructive nationalism. They violently oppose private enterprise and especially foreign investment. This is the atmosphere and political climate in which the communists thrive. They form alliances with this leadership and create new blocks to private investment.

Now the communists are engaged in relentless political and economic warfare against the United States and the rest of the "free world," as a part of their main objective of world domination. The issue is totalitarian socialism versus democracy, freedom, and private enterprise and initiative.

As I understand it, one important part of the U. S. Government policy in waging this battle is to do everything possible to promote strong, healthy economic growth at home and to cooperate with, assist, and encourage other countries in economic growth and development, with particular emphasis on weaker and less developed nations.

Principal weapons in the struggle are:

1. *Increased international trade.*
2. *Foreign loans and grants in aid.*
3. *Technical assistance.*
4. *Private investment.*

When we consider the size of the job to be done and the number of countries involved, it seems quite obvious that the U. S. Government and its taxpayers can supply only a minor share of the capital required and that the lion's share must be provided by local and foreign private capital.

Viewed in this perspective, it seems to me that the problems of the manager overseas involve a very heavy responsibility to his company, his country, and to the entire free world. ★ ★ ★

H. W. HAIGHT, *now director and vice president of Humble Oil and Refining, is an authority on management abroad.*

After obtaining his degree in geological engineering from Colorado School of Mines, 1927, he joined Jersey Standard as a torsion balance party chief with Cia. Transcontinental de Petroleo, S. A., a Mexican affiliate. In 1938 Haight became manager of Standard of Egypt, in Cairo. He went from there to Venezuela as production manager for Creole and in 1954 he was made president of Creole. In early 1959 he was elected chairman of the board for Carter Oil, and after his company merged with Humble, Mr. Haight took his present position. This article is taken from remarks he made at Desk and Derrick annual convention last year at San Antonio.

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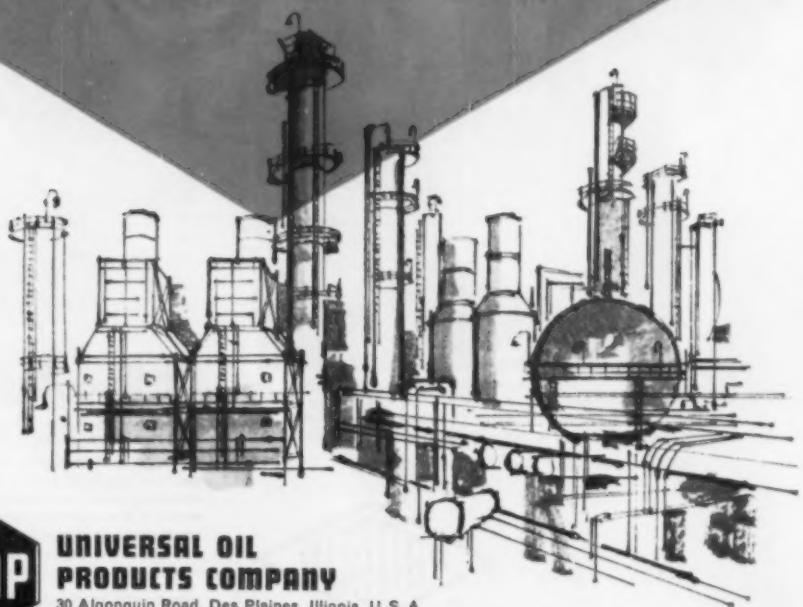

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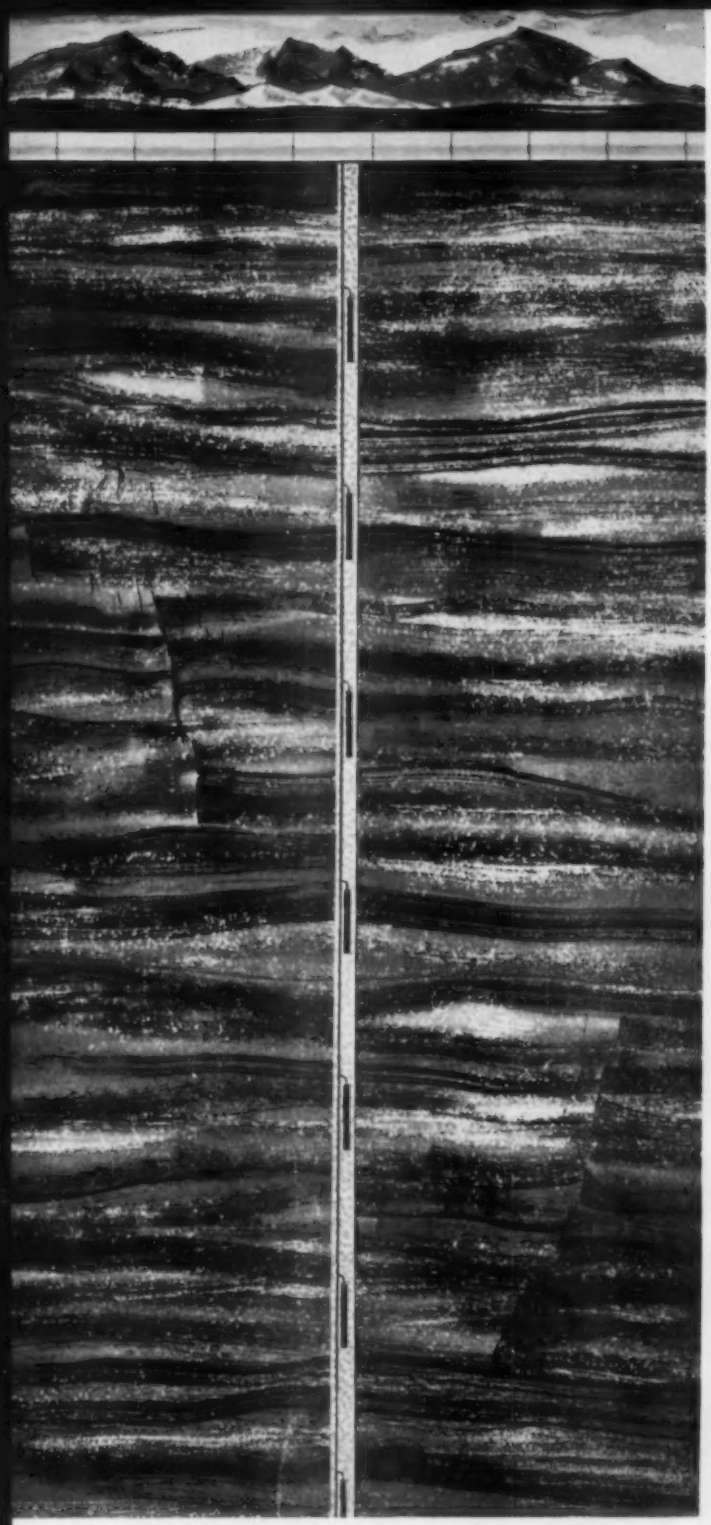

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installation, specify

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Anodes

Durco high silicon iron alloys (Duriron, Durichlor, and D-51) are being used almost exclusively for new deep well anode installations.

Durco anodes combine the advantages of:

1 PERMANENCY *(Weight loss 1/20 of that of steel)*

2 EASE OF INSTALLATION *(Bulk volume of scrap steel is avoided)*

3 MINIMUM TOTAL COST *(No backfill or pre-packing of anodes required)*

Durco high silicon iron alloys are resistant to sea, brackish, and fresh waters, as well as all soil environments. Complete details are contained in Bulletin DA/6.

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DAYTON, OHIO

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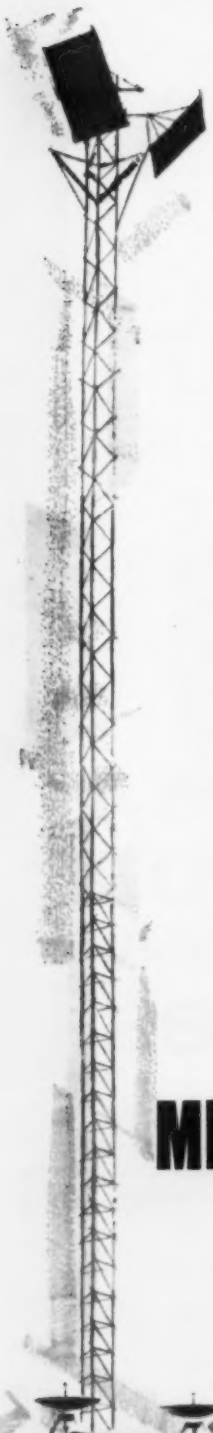


COLUMBIA GAS SYSTEM

plans 470 miles of Collins microwave . . .

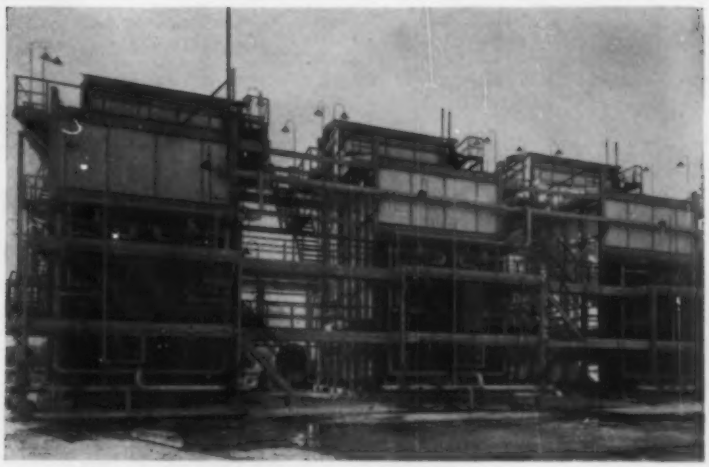
COLLINS MICROWAVE AND CARRIER

United Fuel Gas Company, a subsidiary of The Columbia Gas System, Inc., has ordered the first section of a Collins microwave system. When completed it will span four states and provide this major natural gas utility with complete facilities for voice communication, teletypewriter service, telemetering, supervisory control and data communication. Expandable to 240 channels, the Collins microwave system will be a part of a broad automation program being planned by Columbia.

For information on a microwave-carrier system tailored to your individual needs, contact Collins Radio Company, Texas Division Sales, 1200 North Alma Rd., Richardson, Texas.

COLLINS

COLLINS RADIO COMPANY • DALLAS, TEXAS • CEDAR RAPIDS, IOWA • BURBANK, CALIFORNIA



AT LEFT: Installing a 60,000 lbs/hr unit in a brewery

ABOVE: A battery of 125,000 lbs/hr units in a chemical plant

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Vogt engineering advances can save you money if you have a steam generating problem. Custom-built installations shown, are engineered to assure efficient, dependable steam generation for power, process and heating. Our engineering staff is available to give effective help in the solution of steam generating problems peculiar to a wide variety of operating conditions. Address Dept. 24A-BRE.

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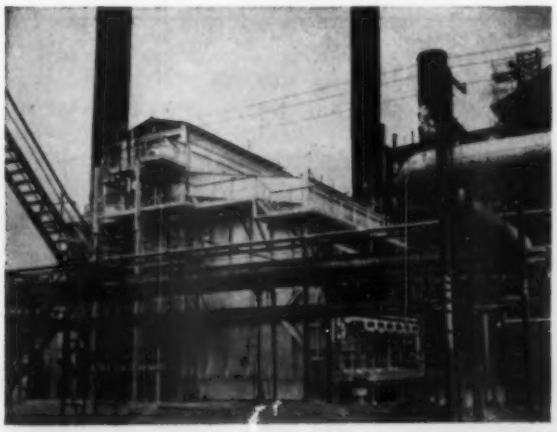
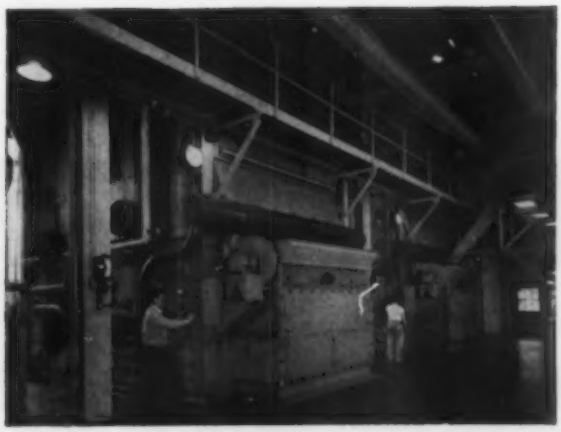
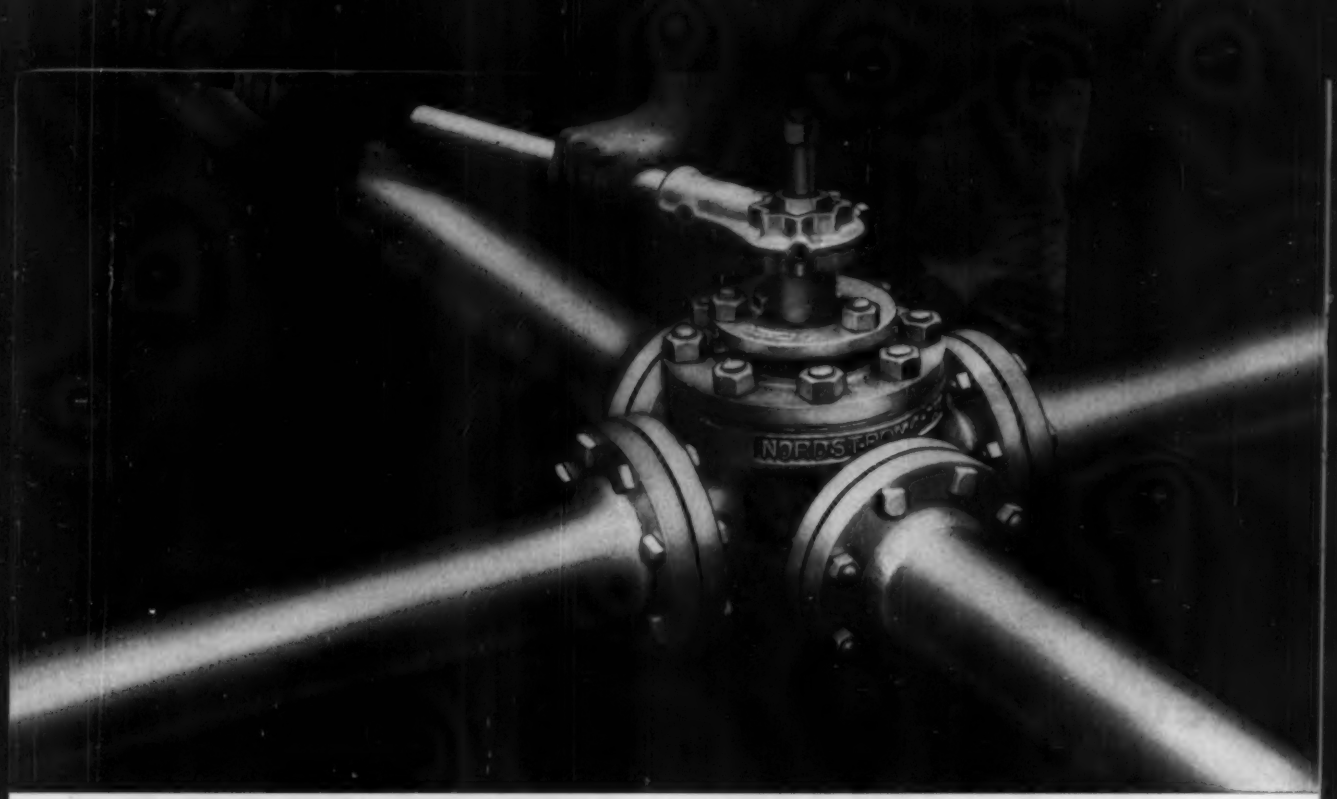


This 400,000 lbs/hr unit is installed in a leading petroleum refinery



Three 40,000 lbs/hr units serve a medical center



Imagine the savings in valves, flanges, piping and fittings made possible by this Rockwell Multiport lubricated plug valve.

HOW TO SOLVE 3 & 4-WAY FLOW PROBLEMS

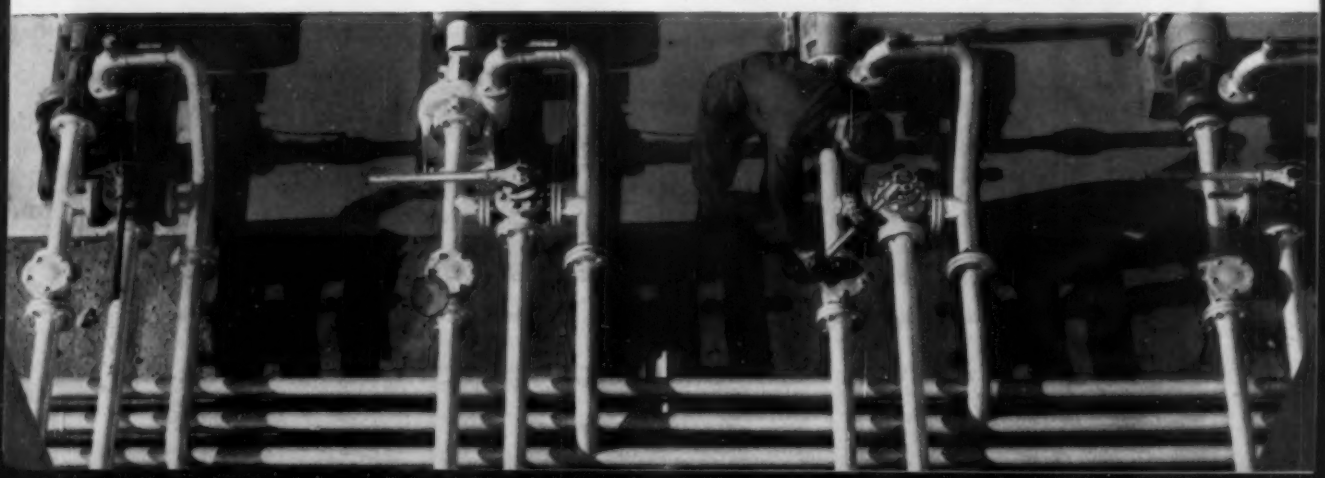
Rockwell-Nordstrom *Multiport* lubricated plug valves can slash costs and reduce operating problems where flow must be shunted in three or four directions. Since one Multiport can replace as many as four conventional valves, initial cost savings are great. Also, the costs of flanges, piping and fittings are substantially cut. Rockwell-Nordstrom Multiport valves can be provided in some 14 different arrangements to suit your manifolding.

Like all other Rockwell-Nordstrom *lubricated* plug valves (the world's most complete line) Multiports stay in service longer and cost less to use. Lubrication prevents metal to metal wear and the vital seating surfaces are never exposed to fouling or contamination by line materials. Write for complete details or have a Rockwell field engineer call. Rockwell Manufacturing Company, Dept. 94-K, Pittsburgh 8, Pa. Canadian Valve Licensee: Peacock Brothers Limited, Montreal. Rockwell International, S.A., Geneva, Switzerland.

Lubrication Makes The Difference

ROCKWELL-Nordstrom VALVES
another fine product by
ROCKWELL

Rockwell-Nordstrom 3-way Multiport valves assure fast, foolproof flow control on petroleum products transfer lines.



What price luxury? Gasoline is taxed more than mink.

Indispensable gasoline is taxed an average 33%, Milady's mink—10%.

When consumers complain, however, about "the high price of gas," they don't seem to know they now pay less (before taxes) for 100 octane gasoline than they did for 50 octane thirty-five years ago. They don't know that two gallons now do the work of three, saving them millions of dollars each year. They don't know, but you do. Next time you get a chance, tell them about it.

SHELL OIL COMPANY

GLOBAL NOTEBOOK

Bright Spot in the Far East –

THE PHILIPPINE ISLANDS

BENJAMIN M. GOZON

WHEN A COMMERCIAL oil well was discovered in the Republic of the Philippines in 1959, it was only another indication that the vast archipelago has important oil possibilities.

Republic Resources Development Corporation found oil at Reina Regente No. 1. Drilled to 1335 ft at a location near Toledo, West Central Cebu, tests showed a 70 b/d production of 43 gravity oil. Later R.R. No. 1-A-X, a confirmation well, was drilled to 6015 ft. Tests indicated 100 b/d output from a new zone. A third well R. R. No. 2-A also has oil.

Standard Vacuum Oil Company (Stanvac) made a gas discovery in 1958 at its Ipil No. 1 well in Cagayan Valley. Subsequent tests of the structure were made in 1959 in three step-out wells. Stanvac believes that the discovery is a small gas accumulation.

Petroleum Code

The Petroleum Act of 1949 puts administration into the hands of Secretary of Agriculture and Natural Resources, who works through the Bureau of Mines. Oil development is reserved to Filipinos or companies with 60% domestic interests. U. S. citizens "and all forms of business enterprises owned

THE LURE OF THE PHILIPPINES

Last year the first commercial oil well was completed in the Philippines just 63 years after the first wildcat of record was drilled there.

The search for oil in the beautiful archipelago of the Far East is a story of persistence and of tantalizing evidences that encourage the wildcatters over wide areas. It is mostly a tale of small operators who have explored the thousands of islands (there are more than 7000) searching for the energy fuel that the nation spends almost 10% of its exchange to import.

Stanvac has been at the forefront of major company exploration, investing a reputed $6 million in exploration. Some Filipino companies would like to have more U. S. company backing — for technical and financial help in evaluating their concessions.

The Republic is better off in refining. The 25,000 b/d Caltex plant runs almost at capacity. Stanvac is building a 25,250 b/d plant and others are in various stages of engineering and construction. Philoil (Gulf 20%) has begun construction. Shell (Filipino interests 25%) plans are advanced.

Consumption of oil products in the Republic has in the last 9 years registered a steady 8% increase each year. The Philippines is a rich country, with fertile lands and a more stable political—and economic life than most Far East countries enjoy. Oil would be a boon to the Republic and the evidence says it is there.

There is opportunity here in a business climate that few nations offer U. S. firms. The Philippines, as many world-weary U. S. travelers report, is like getting home.

PHILIPPINES ESTIMATED INLAND CONSUMPTION IN EQUIVALENT BARRELS

	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959
Motor gasoline	3,926,961	3,862,451	4,139,459	4,440,663	4,833,451	5,242,960	5,538,573	5,882,771	6,013,617	6,358,543
Kerosene*	1,180,079	1,150,405	1,208,110	1,305,706	1,390,412	1,594,102	1,524,558	1,604,704	1,672,243	1,762,869
Diesel Fuel	2,208,269	2,295,766	2,520,384	2,662,539	2,758,465	3,008,813	3,338,270	3,603,618	3,787,717	4,104,801
Fuel Oil	1,685,529	1,692,500	1,886,388	2,067,257	2,377,368	2,529,069	2,908,034	3,312,884	4,197,903	5,150,538
Lube Oils	166,833	212,523	215,746	230,381	233,700	254,696	276,302	265,510	289,773	322,614
Greases	22,394	24,500	21,775	22,205	39,600	43,058	50,592	45,701	49,492	59,613
Total	9,190,065	9,238,145	9,991,862	10,728,751	11,632,996	12,672,698	13,636,329	14,715,188	16,010,745	17,758,978
Barrels per day	25,178	25,310	27,300	29,394	31,871	34,720	37,258	40,316	43,865	48,655
Increase rate	–	+1%	+8%	+8%	+8%	+9%	+7%	+8%	+9%	+11%
International bunkers† b/d	NA	1,709	1,237	2,729	2,787	2,598	1,390	1,293	548	355

*Beginning 1955 this includes jet fuel.
†Inter-island marine craft consumption included in inland consumption.

The 24,500 b/d refinery of Caltex (Philippines) Inc. at Batangas. This is the first refinery to be built in the Philippines and is the nation's largest single industrial plant.
— Photo courtesy of California Texas Oil Company.

and controlled, directly and indirectly by citizens of the United States shall enjoy the same rights and obligations under the provisions of this Act in the same manner as citizens of the Philippines."

Concessions may be any of the following kinds:

a. Non-exclusive exploration permit grants to the permittee the non-exclusive right to conduct geological or geophysical exploration on specified areas.

b. Exploration concession grants to the concessionaire exclusive right to explore for petroleum within specified areas.

c. Exploitation concession grants exclusive right to develop petroleum production within the specified areas.

d. Refining concession grants the right to manufacture or refine petroleum, or to extract its derivatives.

e. Pipe line concession grants the right to provide and operate pipe line systems for transporting petroleum.

In the disposition of the National Reserve Areas (relinquished areas) and in case of conflicts of applications for concessions, additional benefits to the Government over and above the minimum requirements may be required. These include bonuses or cash payments, increased royalty or undertakings in addition to those required by law.

During the first five years following the granting of any concession, the concessionaire may import free of customs duty, all equipment, machinery, material, instruments, supplies and accessories.

Prior to the issuance of a concession, except the non-exclusive exploration permit, a bond shall be posted.

The *non-exclusive permit* can be obtained for two years, renewable for two years by the Director of Mines. This allows geological and geophysical work preparatory to applying for a concession.

An *exploration concession* covers an area from 20,000 to 100,000 hectares. One person or firm can hold a maximum of one million hectares, but not more than 500,000 hectares in one region. (See map for six regions.) Concession is for 4 years, twice renewable for 3-year periods. One thousand pesos is paid with the application and returned, less expenses, if not granted.

Expenditures for exploration operations must amount to:

Initial term: First year, not less than 50 centavos/hectare; second, one peso; third, one peso and 50 centavos; fourth year, two pesos/hectare.

First extension: Two pesos and 50 centavos/hectare/year.

Second extension: Three pesos/hectare/year.

The annual exploration tax for these concession holders runs: First year, 5 centavos/hectare; second and third, 7½ centavos; fourth, 10 centavos. First extension: 10 centavos/year. Second extension: 12½ centavos/year.

The *exploitation concession* can be granted at any time to an exploration concessionaire for 25 years, renewable for 25 years. It covers a maximum of one half the exploration concession and no person can hold more than 250,000 hectares in any one petroleum region nor more than 500,000 hectares in the Republic. Application fee is 2000 pesos, returned if concession is not granted.

Annual exploitation tax per hectare is: First 5-year period, 50 centavos; second 5-year, one peso; third 5-year, one peso and 50 centavos; fourth, 3 pesos; fifth, five pesos, and during the period or periods of its renewal five pesos/hectare/year.

Royalty is 12½% of production, less field use. Reinjected natural gas shall not be subject to royalty.

A refining concession may be granted an exploitation concessionaire or any other qualified person, including a discoverer of oil seep or gas for 25 years' duration, renewable for 25 years. The concessionaire may renounce his refining concession or transfer it at any time with prior government approval.

A non-exclusive 25-year *pipeline concession* is guaranteed to the exploitation concessionaire. It is renewable for 25 years additional.

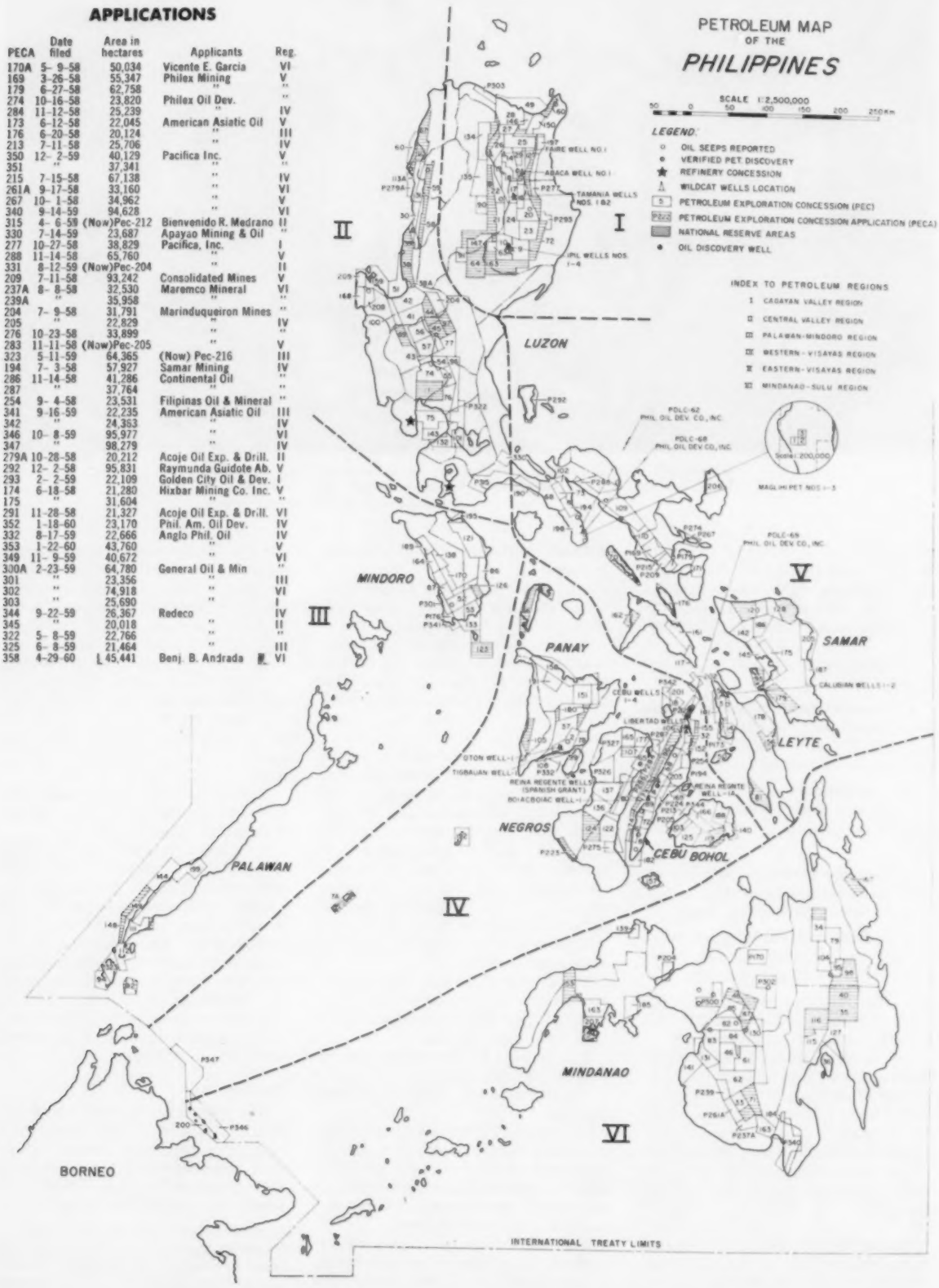
Geology*

Just before the outbreak of World War II Grant W. Corby conducted a nationwide petroleum survey for the then Commonwealth government at the request of President Quezon. He found real possibilities of oil in the

*EDITOR'S NOTE: Shortly The Petroleum Engineer, Drilling and Producing, will carry an article by Dr. Gozon on Philippine geology, which will supplement this brief description.

APPLICATIONS

PECA	Date filed	Area in hectares	Applicants	Reg.
170A	5- 9-58	50,034	Vicente E. Garcia	VI
169	3-26-58	55,347	Philex Mining	V
179	6-27-58	62,758	"	"
274	10-16-58	23,820	Philex Oil Dev.	"
284	11-12-58	25,239	"	IV
173	6-12-58	22,045	American Asiatic Oil	V
176	6-20-58	20,124	"	III
213	7-11-58	25,706	"	IV
350	12- 2-59	40,129	Pacifica Inc.	V
351	"	37,341	"	"
215	7-15-58	67,138	"	IV
261A	9-17-58	33,160	"	VI
267	10- 1-58	34,962	"	V
340	9-14-59	94,628	"	VI
315	4- 6-59	(Now)Pec-212	Bienvenido R. Medrano	II
330	7-14-59	23,687	Apayao Mining & Oil	"
277	10-27-58	38,829	Pacifica, Inc.	I
288	11-14-58	65,760	"	V
331	8-12-59	(Now)Pec-204	"	II
209	7-11-58	93,242	Consolidated Mines	V
237A	8- 8-58	32,530	Maremco Mineral	VI
239A	"	35,958	"	"
204	7- 9-58	31,791	Marinduqueiron Mines	"
205	"	22,829	"	IV
276	10-23-58	33,899	"	"
283	11-11-58	(Now)Pec-205	"	V
323	5-11-59	64,365	(Now) Pec-216	III
194	7- 3-58	57,927	Samar Mining	IV
286	11-14-58	41,286	Continental Oil	"
287	"	37,764	"	"
254	9- 4-58	23,531	Filipinas Oil & Mineral	"
341	9-16-59	22,235	American Asiatic Oil	III
342	"	24,353	"	IV
346	10- 8-59	95,977	"	VI
347	"	98,279	"	IV
279A	10-28-58	20,212	Acoje Oil Exp. & Drill.	II
292	12- 2-58	95,831	Raymunda Guidote Ab.	V
293	2- 2-59	22,109	Golden City Oil & Dev.	I
174	6-18-58	21,280	Hixbar Mining Co. Inc.	V
175	"	31,604	"	"
291	11-28-58	21,327	Acoje Oil Exp. & Drill.	VI
352	1-18-60	23,170	Phil. Am. Oil Dev.	IV
332	8-17-59	22,666	Anglo Phil. Oil	IV
353	1-22-60	43,760	"	V
349	11- 9-59	40,672	"	VI
300A	2-23-59	64,780	General Oil & Min	"
301	"	23,356	"	III
302	"	74,918	"	VI
303	"	25,690	"	I
344	9-22-59	26,367	Redeco	IV
345	"	20,018	"	II
322	5- 8-59	22,766	"	"
325	6- 8-59	21,464	"	III
358	4-29-60	45,441	Benj. B. Andrada	VI



CONCESSIONS IN THE REPUBLIC OF THE PHILIPPINES

PEC	Date Granted	AREA IN 1000 Hectares	CONCESSIONAIRES	REMARKS	
2	10-29-52[2]	71,939	Phil. Oil Dev. Co.		IV
4	5- 4-55	25,435	Phil. Oil Dev. Co.		IV
5	7-25-55	21,158	"		V
6	"	25,016	"		IV
8	12-23-55	54,100	Acoje Oil Exp. & Dr.	Portion Out[1]	"
9	12- 9-55	93,218	Standard Vacuum	"	I
10	"	89,061	"	"	"
11	"	25,513	"	"	"
12	"	36,261	"	"	"
13	"	24,620	Anglo Phil. Oil	(Now) Pec-146	"
14	"	46,574	Standard Vacuum		"
15	"	39,691	"		"
16	"	33,409	"		"
17	12-17-56	44,909	Phil. Oil Dev. Co.		"
18	"	37,128	"		"
19	"	50,661	"		"
20	"	85,799	"	Portion Out[1]	"
21	"	98,820	"	"	"
22	"	84,364	"	"	"
23	12-27-56	61,208	Caltex (Phil.) Inc.	Assigned to:	"
24	"	91,966	"	Texaco Overseas	"
25	"	86,878	" P.R.	& Calif.	"
26	"	86,586	" "	Asiatic	"
27	"	43,360	" "	jointly	"
28	"	99,603	" "		"
29	"	29,419	"		"
30	1-31-56	41,662	Philex Oil Dev.		II
31	"	59,866	"		"
32	2-20-57	29,451	Acoje Oil Exp. & Dr.		IV
33	6- 6-56	79,387	San Jose Oil Co.	Portion Out[1]	VI
34	"	93,228	"	"	"
36[3]	"	26,697	"		"
37	"	98,878	"	Portion Out[1]	IV
38	"	78,650	"	Portion Out[1]	II
41	6-25-56	69,664	"		II
42	"	99,999	"		"
43	"	17,194	"		"
44	"	57,263	"	Portion Out[1]	"
45	"	44,884	"	"	"
46	"	99,999	"	"	VI
49	2- 6-57	86,051	White Eagle Overseas		I
50	"	37,988	"		V
51	"	85,563	"		II
52	2-18-57	99,999	Rep. Resources & Dev.	Portion Out[1]	III
53	"	52,417	"		"
54	"	37,875	"		II
55	"	33,413	"		"
56	6- 3-57	70,138	PHIL. OIL. DEV. CO.		"
57	"	65,740	"		"
58	6- 5-57	63,062	Acoje Oil Exp. & Dr.	Portion Out[1]	"
59	"	37,374	"	"	"
61	8-15-57	99,979	Maremco Mineral		VI
62	"	99,039	"		"
63	7- 3-57	91,877	"	Portion Out[1]	I
65	"	62,458	"		IV
68	"	87,438	"		V
72	8-12-57	27,696	Rep. Resources & Dev.		IV
73	"	31,040	"		V
74	"	83,678	"		II
75	"	74,794	San Jose Oil Co.		"
76	"	99,919	"		"
77	8- 9-57	70,560	Phil Oil Dev. Co.		"
78	"	33,288	"		IV
79	8-15-57	85,618	San Jose Oil Co.		VI
80	8-30-57	96,849	Madrigal & Co.		IV
82	5-12-58	67,108	Hixbar Mining Co.		VI
83	"	83,056	"		"
84	"	96,457	"		"
85	"	79,212	"		"
86	"	60,901	"	Portion Out[1]	III
87	"	71,561	"		"
88	"	34,000	"		IV
89	"	35,861	"		"
90	"	35,222	"		I
91	"	30,394	"		I
92	9-30-57	39,844	Samar Mining Co.	Portion Out[1]	III
94	"	43,822	Marinduque Iron Mines		III
95	10-29-57	38,356	San Jose Oil Co.		VI
96	12-18-57	50,292	Rep. Resources & Dev.		II
99	12-24-57	41,650	"	Portion Out[1]	IV
100	1- 8-58	32,138	"	"	II
101	2-14-58	54,254	Rep. Resources & Dev.		II
102	"	30,385	"		V
103	"	49,360	"	Portion Out[1]	IV
104	"	52,035	"		VI
105	5-20-58	57,200	America Asiatic Oil	Portion Out[1]	IV
106	"	24,466	"	"	"
107	7-29-58	39,687	Anglo Phil Oil	Portion Out[1]	"
108	8- 5-58	21,042	San Jose Oil Co.		"
109	8- 6-58	99,981	Baguio Gold Mining		V
110	"	48,838	"		"
111	8-21-58	67,020	Samar Mining Co.	Portion Out[1]	III
112	"	74,590	Marinduque Iron Mines		"
113	8-22-58	83,712	Acoje Oil Exp. & Dr.	Portion Out[1]	II
114	"	60,559	"	"	V
115	"	91,674	"	Portion Out[1]	VI
117	8-26-58	38,984	American Asiatic Oil		V
118	"	20,540	"		IV
119	"	82,324	"	Portion Out[1]	"
120	9-22-58	95,323	Filipinas Oil & Mineral	Portion Out[1]	V
121	9-25-58	99,894	Anglo Phil. Oil		III
122	"	81,351	"		IV
123	"	70,770	"		III
125	9-10-58	78,600	Rep. Resources & Dev.		IV
126	"	27,356	"		III
127	10- 3-58	99,327	Filipinas Oil & Mineral	Portion Out	VI
128	"	99,139	"	"	V
129	"	87,504	"	"	VI
130	"	85,766	"	"	"
131	10-22-58	97,594	Pacifica, Inc.	Portion Out[1]	"
132	"	64,272	Anglo Phil. Oil		II
133	10-23-58	53,852	Consolidated Mines		III
134	"	84,560	"	Portion Out	I
135	"	98,672	"	"	"
136	11- 7-58	99,961	Raymunda Guidote Abila		IV
137	"	83,854	"		"
138	12-12-58	21,977	Continental Oil Co.		III
140	"	29,754	"		IV
141	"	58,746	"		VI
142	"	64,478	"		V
143	12-16-58	41,448	Pacifica, Inc.		II
145	"	95,325	"		V
146	12-17-58	24,620	Anglo Phil. Oil	Portion Out[1]	I
148	"	28,650	Rep. Resources & Dev.	Portion Out	III
149	"	87,862	"	"	"
150	12-19-58	29,824	Apayao Mining & Oil		I
151	"	63,400	"	Portion Out	IV
152	1-14-59	22,903	Marinduque Iron Mines	Portion Out[1]	"
155	"	22,273	"	Portion Out[1]	IV
157	"	45,008	Baguio Gold Mining		IV
158	1-20-59	98,409	J. Amado Araneta		"
159	1-23-59	87,970	Unit. Asia Oil & Mining		II
160	"	35,374	"		"
161	1-26-59	56,253	Samar Mining Co.	Portion Out[1]	V
163	1-27-59	72,220	"	Portion Out[1]	VI
164	2-26-59	33,114	Phil. Am. Oil Dev.	"	III
166	"	41,794	"	Portion Out[1]	IV
168	"	32,298	"	Portion Out[1]	II
169	"	22,034	"		IV
171	3- 3-59	41,115	"		V
172	"	64,707	"	Portion Out[1]	I
173	5-12-59	51,383	"	Portion Out[1]	IV
174	"	36,273	"	"	"
176	6-15-59	38,535	Anglo Phil. Oil	Portion Out[1]	V
177	"	29,754	"		IV
178	"	81,488	"		V
179	"	97,580	"	Portion Out[1]	V
180	"	54,334	"	"	IV
181	4-17-59	20,024	Manila Mining		V
182	7-23-59	44,681	Continental Oil		IV
183	"	50,898	Golden City Oil		VI
184	"	38,652	"		"
185	"	41,007	"		"
186	"	44,874	"		V
187	"	38,828	"		"
188	"	42,572	"		IV
190	9-29-59	30,176	Apayao Mining & Oil		V
191	10- 1-59	40,342	J. Amado Araneta		IV
192	"	51,205	"		"
193	"	63,509	"		"
194	10- 5-59	26,981	Acoje Oil Exp. & Dr.		V
195	10-20-59	20,070	Anglo Phil. Oil	Portion Out[1]	III

Continued

PEC	Date Granted	AREA IN 1000 Hectares	CONCESSIONAIRES	REMARKS	
196	10-20-59	80,842	Angle Phil. Oil	Portion Out[1]	IV
198	10-22-59	78,353	White Eagle Overseas		V
199	11- 3-59	64,042	Am. Asiatic Oil		III
200	"	71,981	"		VI
201	"	22,470	"		IV
202	"	23,258	"		V
203	11-11-59	36,066	Phil. Am. Oil Dev.		IV
204	11-25-59	47,197	Pacifica, Inc.		II
205	12- 2-59	88,257	Marinduque Iron Mines		V
206	1-19-60	59,493	Bulacan Iron Mines		"
207	"	36,245	"		VI
208	1-29-60	32,855	Angio Phil. Oil		II
209	"	29,334	"		"
210	2-23-60	83,388	"		IV
211	"	96,470	"		"
212	3-28-60	99,115	Bienvenido R. Medrano		II
213	5- 4-60	21,767	Am. Asiatic Oil Corp.		IV
214	5-16-60	20,098	Angio Phil. Oil Corp.		"
215	5-17-60	22,393	Am. Asiatic Oil Corp.		"
216	5-17-60	64,365	Mar. Iron Mines Agents		III

[1]No. 1 was cancelled as are other PECs where number is missing.

its activities: "Exploration work in the Philippines includes thorough geological and geophysical studies, designed and oriented toward the proper evaluation of the oil and gas potentialities in each area. Supplementing this program are geological field surveys and air-photo interpretation for the surface geology phase, utilization of selected geophysical methods and equipment and drilling of shallow test wells to get a complete picture of the subsurface geology of each area."

This year White Eagle carried out initial studies by drilling a number of shallow wells within the onshore concessions. These wells have two objectives. They are supplying detailed data on the stratigraphy and structure of the subsurface, and they are being drilled in locations which, according to surface indications, offer the greatest promise for oil and gas discovery.

Philex Oil Development Company has done geological mapping, aerial magnetometer survey, drilled one diamond drill hole to a depth of 2905 ft, and made seismograph surveys. The company plans to drill one and possibly two wells in the Candon area, Ilocos Sur, beginning in 1960.

Since 1956, San Jose Oil Company (Pantepec 36%), which has large holdings, has conducted airborne and ground magnetometer surveys, land and

Philippines and in 1951 published his findings.†

There are seven major sedimentary basins in the Philippines. Cagayan Valley Basin on Luzon is in Region I. Wells drilled here went nearly to 14,000 ft without reaching basement rocks.

Central Valley Basin in Region II is on the west side of Luzon. Three anticlinal structures were marked by Corby in 1951.

Southeast Luzon Basin is almost all in Region V, the tip running into Region II.

East-Central Visayan Basin has Cebu at its core. Numerous oil seeps have been seen here since the Spaniards arrived. Mostly in Region IV and extending into Region V, it is here where the first commercial oil well was completed in 1959.

Iloilo Basin, about 258,000 hectares, is in Southeast Panay, in the same Region IV. The center is covered with a thick layer of alluvium and geophysical methods must be used to locate subsurface structures. Several have been found.

Agusan-Davao Trough on the East and Cotabato, in the Southwest of Mindanao Island are both in Region VI.

Geological work is a great portion of all exploration work so far. Party months in 1959 reached 353.

Exploration

Besides the 353 geological party months, there were 81 geophysical party months carried out in 1959.

Sixteen companies did extensive surveying. Luzon received the most attention with Caltex and Philippine Oil Development Company (Podco) combining and Stanvac, Anglo-Philippine, Consolidated Mines and White Eagle all doing geological work in the Cagayan Basin. The first three had geophysical crews in the area.

Here is how White Eagle reported

† Corby, Grant W. et al, "Geology and Oil Possibilities of the Philippines," Republic of the Philippines, Department of Agriculture and Natural Resources, Technical Bulletin 21, (1951).

DEEP EXPLORATORY WELLS DRILLED IN THE PHILIPPINES

Name	PEC	Region	Location	Company	Spudded	Completed	Depth	Results
1. Sapa #1			Bondoc Pen.	Richmond Pet.	12-26-21	9- 2-23	3,750	Gas show.
2. Pina #1			Bondoc Pen.	Richmond Pet.	6-10-22	4-24-24	5,135	Gas and oil shows.
3. Barili #1a			Barili, Cebu	Nat'l. Dev.	1938		3,500	
4. Cebu #1			Daanbantayan, Cebu	Phil. Oil Dev. & Far East Oil	9- -40	2- -42	8,326	Demolished due to war.
5. Cebu #2	PDLC 69	IV-D	Daanbantayan, Cebu	Phil. Oil Dev.	4-19-47	9- 7-47	9,950	Oil and gas shows mainly in limestone.
6. Bondoc #3	PDLC 68	V-D	Bondoc Pen., Quezon	Phil. Oil Dev.	5-31-48	7- -49	5,548	Dry.
7. Cebu #3	PDLC 69	IV-D	Daanbantayan, Cebu	Phil. Oil Dev.	9-18-48	12-12-49	7,469	Some gas.
8. Macabebe #1	1	II-D	Macabebe, Pampanga	Phil. Oil Dev.	6- 9-50	6-20-50	4,215	Dry.
9. Manalin #1	1	II-D	Manalin, Pam.	Phil. Oil Dev.	7- 8-50	7-14-50	4,215	Dry.
10. Cebu #4	PDLC 69	IV-D	Daanbantayan, Cebu	Phil. Oil Dev.	8-14-50	12-23-50	5,909	Gas shows.
11. Oten #1	2	IV-D	Oten, Iloilo	Joint venture Phil. Oil Dev.	1-20-53	2-11-53	6,354	Dry.
12. Tumauini	17	I-D	Mallig, Isabela	Phil. Oil Dev.	1-12-56	9-18-56	10,414	Gas shows. Lost hole at 10,414 ft.
13. Faire #1	14	I-D	Faire, Cagayan	Stanvac	3-23-57	8-27-57	10,324	Oil gas traces. Steeply dipping beds.
14. Tumauini #2	17	I-D	Mallig, Isabela	Phil. Oil Dev.	6- 3-57	12-22-57	13,512	Low vol., high press. Gas in sand stone in siltst; 120 lb/gal. mud. High cost.
15. Libertad #1	32	IV-D	Bego, Cebu	Acoje	12-12-57	3- 9-58	5,824	Gas show.
16. Ipil #1	10	I-D	Echague, Isabela	Stanvac	6- 7-58	7-25-58	7,260	Dry.
17. Abaca #1	15	I-D	Penablanca, Cagayan	Stanvac	9-18-58	1-28-59	7,954	Basalt basement.
18. Calubian #1	5	V-D	Calubian, Leyte	Phil. Oil Dev.	11-14-58	5-31-59	8,370	—
19. Ipil #2	10	I-D	Echague, Isabela	Stanvac	2-11-59	5- 6-59	8,570	Volcanics basement.
20. Ipil #3	10	I-D	Echague, Isabela	Stanvac	5-14-59	7-23-59	10,271	—
21. Bogo #1 (Libertad 23)	32	IV-D	Bogo, Cebu	Acoje	5-24-59	9-12-59	8,281	Gas show.
22. Ipil #4	10	I-D	Echague, Isabela	Stanvac	7-29-59	9-15-59	6,294	—
23. Reina Regente #1-A	SPG 24(4)	IV-D	Toledo, Cebu	Redeco	8-20-59		1,335 (casing)	Completed oil well.
24. Tigbuan #1	2	IV-D	Oten, Iloilo	Phil. Oil Dev.	9-16-59	1-11-60	7,485	Little gas.
25. Reina Regente #1-A-X	SPG 24(4)	IV	Toledo, Cebu	Redeco	10- 5-59		6,015 2,065 (casing)	Completed oil well.
26. La Paz #3	32	IV	Bogo, Cebu	Acoje	10-17-59	11-14-59	4,284	—
27. Illuru #1	26	I-D	Rizal, Cagayan	Caltex	10-30-59	1-12-60	10,243	Dry.
28. Villalon #1	4	IV	Toledo, Cebu	Redeco	1-19-60	2- 4-60	3,639	Dry.
29. Rizal #1	10	I	Santiago, Isabela	Stanvac	1-29-60	5-17-60	9,198	—
30. Narra #1	9	I	Echague, Isabela	Stanvac	6- 9-60	7-13-60	4,845	—

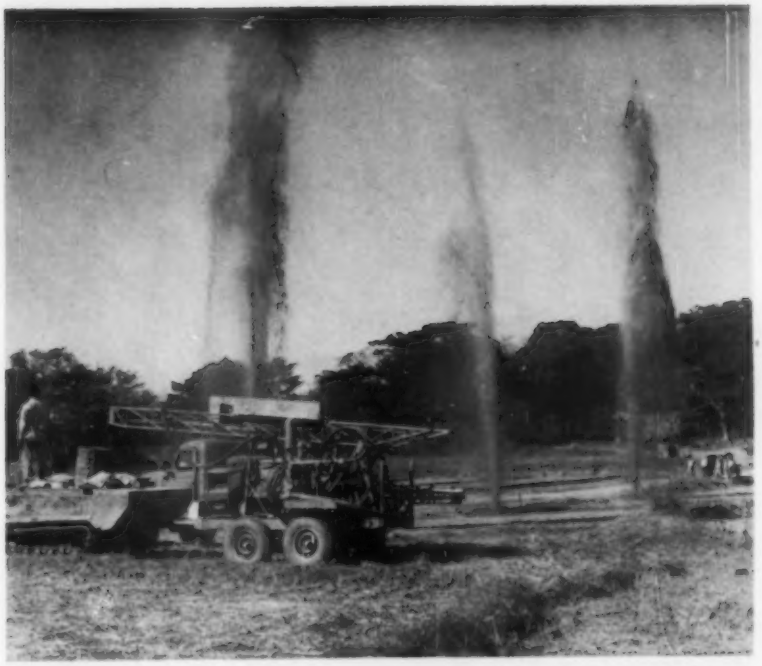


Photo courtesy of San Jose Oil Company.

Seismic work performed in the Luzon Central Valley for San Jose Oil Company by Century Geophysical Corporation.

marine gravity meter surveys, and seismic surveys, as well as geological surveys. At present the company is performing seismic and geologic work preparatory to drilling next year.

Besides completing reconnaissance geologic survey of its four concessions and detailed surface geology of two anticlines in one of the concessions, Consolidated Mines, Inc. will have a gravity survey of certain areas in the concessions and later make a seismic survey on favorable structures. Drilling plans depend on survey results.

Conoco is preparing for gravity and magnetic surveys, seismic work, and eventual drilling.

Filipinas Oil and Mineral Corporation completed reconnaissance and semi-detailed geological mapping of its four concessions, has done gravity work in two in Mindanao, Davao and Cotabato. Reconnaissance surveys have been made in two other concessions the company is applying for. Plans are to use gravity meter surveys for reconnaissance work and seismograph surveys for detailed information before starting a drilling program.

Diamond drill for shallow holes is part of Baguio Gold Mining Company's plans for Pecs 109 and 110.

Golden City Oil and Development Corporation, which has 7 exploration concessions reports its program of exploration and drilling for the ensuing year calls for detailed geological studies of structures delineated by photogeology and, if warranted, drilling of wells for structure and stratigraphy.

After geological mapping and some geophysical surveys, Marinduque Iron Mines Agents are continuing a reconnaissance gravity meter survey on three of its four exploration concessions and a seismic survey of promising areas. Three locations will have stratigraphic drilling. Plans are to drill a few sites where oil shows occur and detailed mapping has been completed.

Drilling

The table of wells includes only those below 3000 ft. Records show 107 wells since Smith, Bell and Company drilled in Toledo, Cebu in 1896. The company drilled two wells, the deeper 1300 ft and both had oil shows.

Most wells have gone down since 1957. Redeco (Republic Resources), which found the first commercial well, actually made the discovery in the first well it drilled outside of shallow stratigraphic tests in the area. Of the six wells drilled at Toledo by Redeco, three are oil wells and three dry.

Podco has probably drilled as many wells as any one company. Beginning in 1941 in northern Cebu, Podco has drilled 25 wells, 2 jointly with Caltex and four with Redeco.

Deepest well in the Philippines is Tumauini No. 2 in North Luzon, drilled to 13,512 ft in 1957 by Podco, Texaco Overseas, California Asiatic.

Stanvac has an aggressive exploration program in the Cagayan Valley, North Luzon. The company's gas discovery, drilled to 7260 ft, had an absolute open flow potential after acidizing of 14,000 mcf/d. Of the 7 deep wells Stanvac has completed in the area two were below 10,000 ft, all below 6,000 ft.

Acoje Oil Exploration and Drilling has completed three deep wells and is drilling a fourth in Central Cebu.

White Eagle drilled 11 wells, 6 on its Northwestern Leyte concession and 5 on the Camotes Islands (Cebu). The 6 on Leyte were drilled within the first 3 months of 1960 after which the company rig was moved to the Camotes where a test program is currently in progress. Depth of each of these wells was approximately 1500 ft.

Sante Fe Drilling Company is the only contractor on the scene.

Plants: One, Three Coming

The Republic of the Philippines is dependent on oil for its chief energy resource but not until 1954 did it have a refinery.

Caltex (Philippines) Inc. Batangas (Luzon) refinery went onstream July 30, 1954 and was originally designed to run 13,500 b/d. In order to keep pace with the growing demand for petroleum products, however, there have been three subsequent expansions of the original refinery design. In 1956 the Batangas refinery was expanded to 15,000 b/d; in 1957 it was enlarged to 18,000 b/d, and this year capacity was firmed up to 24,000 b/d.

Caltex has the only refinery operating at present in the Philippines. Major process units are: 22,000 BPSD crude unit; decarbonizing unit 3000 BPSD; fluid catalytic cracking unit 7500 BPSD; and polymerization unit 950 BPSD.

Facilities alone represents an initial investment by Caltex of approximately $30,000,000. R. J. Monical is vice president and managing director; R. R. Tillotson is vice president and general manager operations; C. L. Wood is refinery manager.

During 1959 average runs at Caltex were:

Barrels at 60 F	*Per Calendar Day*	*Per Stream Day*
Crude feed	24,495	24,915
Charge to units:		
Vacuum column	13,721	14,517
Fluid cat. cracking unit .	8,744	9,395
Output: Polymerization plant	703	767

The figures above represent actual

figures over a long period and do not necessarily represent maximum capacities.

Standard-Vacuum's new refinery at Limay on the Bataan Peninsula (Luzon) overlooking Manila Bay, is scheduled to start operations early next year. The $45 million catalytic-type refinery with a crude oil throughput capacity of 24,000 b/d will manufacture fuel products and asphalts.

Major processing units include a pipestill, a catalytic cracker, a catalytic reformer, desulfurizing facilities, a catalytic polymerization plant and an asphalt plant.

Several technological features are being incorporated in the refinery. An air-cooling system, using 112 horizontal fans ranging in size from 7 to 12 ft in diameter, will provide 70 to 90% of the refinery's cooling requirements. A high degree of electronic instrumentation will permit a single control center for all process operations.

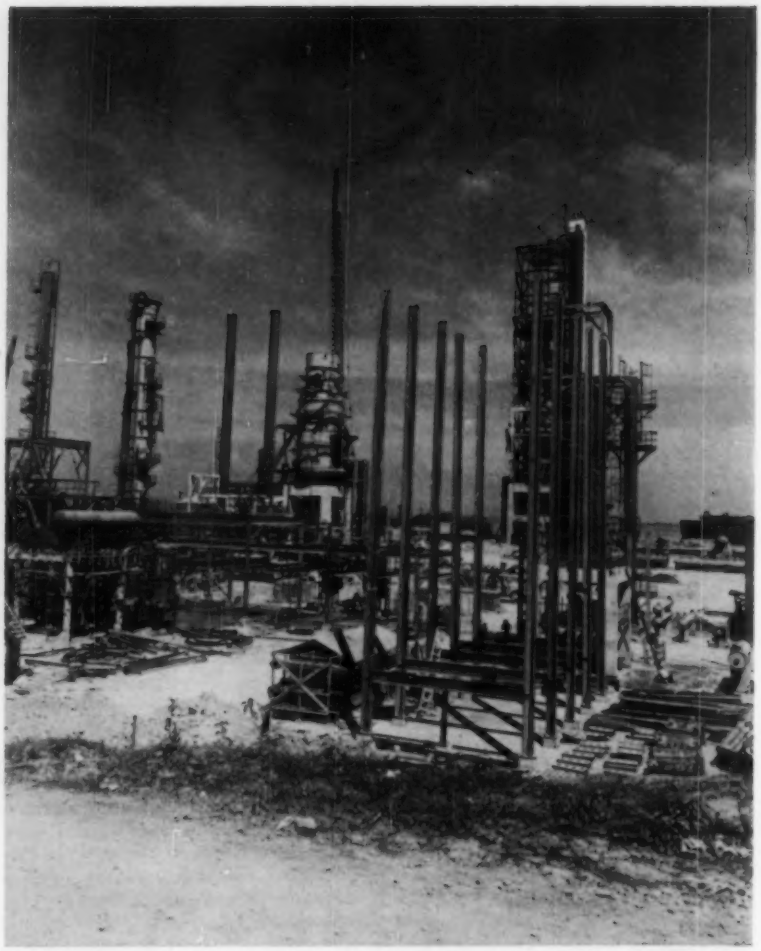
Crude oil will be supplied to the refinery in 87,500-ton supertankers which will be moored 3300 ft offshore in 60 ft of water. Off-loading will be accomplished with the use of a special hose-hoisting device attached to a 28-in. submarine pipeline. The hoister is a long rectangular jib-like structure which lies on the sea bed when not in use. One end is anchored to a platform on the bottom, allowing the other end to rise in the water when compressed air is pumped into its buoyancy tanks. As the free end rises from the floor of the bay it carries with it three 12-in. and one 8-in. flexible hoses which appear on the surface in a vertical position alongside the tanker.

With this equipment, tankers will be able to unload up to 50,000 b/hr. When unloading is completed the buoyancy tanks are filled with water and the entire hoisting structure returns to rest on the sea bottom.

Nineteen Filipino employees, all with university schooling in the Philippines, have been training in the United States and Australia for periods of 6 to 12 months to take over mechanical and process supervisory positions. They will also assist expatriate personnel in the start-up.

Foster Wheeler Corporation is the primary contractor and Socony Mobil Oil Company, Inc., handled the design engineering work.

C. A. Larsen is general manager of Standard-Vacuum Oil Company's Philippines Division and W. H. Hesketh is assistant general manager in charge of refining. Mr. Hesketh is also president of the company's refining subsidiary, Standard-Vacuum Refining Corporation (Philippines). R. E. Pulver, the refinery manager, has the following assistants: R. M. Yates, process superintendent; R. Ellison, chief process engineer; R. B. Weidmann, mechanical superintendent, and J.H.B. Dudley, technical superintendent.



—Photo courtesy of Standard-Vacuum Oil Company.
View of process area of Standard-Vacuum's Bataan refinery project showing guy derrick working on Vacuum Tower.

Filoil Refining Corporation ($30 million capital) is essentially a Philippine project with Gulf Oil holding a minority interest (20%). A 10,000 b/d plant is already under construction in Cavite Province, south of Manila. The refinery was designed by Universal Oil Products and Procon is building it. Gulf supplies technical assistance in construction and will continue to do so after the plant is in operation but management is Filipino.

Young Filipino engineers who will work with Filoil are in the U. S. training for refining operations. One wrote us, "It is only too bad that they do not offer refining engineer courses so I did the next best thing by subscribing to your mazagine" (Our Petro/Chem Engineer).

The fourth refinery is that of Shell Refining Company (Philippines) Inc. and Filipino interests (25%) to be built at Tabangao Batangas. Cost of the 10,000 b/d plant is estimated at approximately $20 million. If contract has been awarded it has not been announced.

A New Horizon

The day before he met his death March 7, 1957, the great President Ramon Magsaysay of the Republic said to a college graduating class: "We have not been training enough people to coax the wealth from the treasure chests of nature into the sunlight of our lives."

Perhaps he would see a new strong trend in that direction if he were here today.

Oil Operators

ABILA-GUIDOTE, RAYMUNDA.
Quezon City: 176 Roosevelt Avenue, San Francisco del Monte. Concessionaire: Mrs. Raymunda Guidote Abila.

ACOJE OIL EXPLORATION & DRILLING CO.
Manila: 5th Floor, Pilot Bldg., Muelle de la Industria. Pres. & Gen. Mgr: Jesus S. Cabarrus.

AMERICAN-ASIATIC OIL CORP.
Manila: 2nd Floor, Gochanco Bldg.; San Luis, Ermita. Pres: Harry S. Stonehill.

ANGLO-PHILIPPINES OIL CORP.
Manila: 421 Singson Bldg., POB 2716, Plaza Moraga. Pres: Howard R. Hick.

APAYAO MINING OIL CO.
Manila: R-436 Regina Bldg., Escolta. Pres. & Chairman: Gaudencio E. Antonino.

ARANETA, J. AMADO.
Quezon City: Cubao. Concessionaire: J. Amado Araneta.

BAGUIO GOLD MINING CO.
Manila: 300 Cortes-Ochoa Building, Dasmarinas. Pres: Henry A. Brimo.

BULACAN IRON MINES.
Manila: 379 Dasmariñas St. Pres: Martiniano G. Abad.

CALTEX (PHILIPPINES) INC.
Manila: P. O. Box 783. VP & Mgr. Dir: R. J. Monical.

CONTINENTAL OIL CO.
Manila: 645 Echague St., Cor. P. Casal St., Quiapo. Pres: Cosme P. Garcia.

CONSOLIDATED MINES
Manila: 501-A China Bank Bldg. Pres: Jose Marino Olondriz.

FILIPINAS OIL & MINERAL CORP.
Manila: Rm. 202 Martinez Bldg., Dasmariñas. Pres: Antonio Tankiang.

GOLDEN CITY OIL & DEV. CORP.
Manila: 502-506 Samanillo Bldg. 378 Escolta. Pres: Teofilo D. Reyes, Jr.

HIXBAR MINING CO.
Manila: Suite 512 Trand & Commerce Bldg., 215 Juan Luna. Pres: Vicente Sayson.

LUZON STEVEDORING CORP. (Lusteveco).
Manila: Tacoma & Second Sts., Port Area. Pres: George W. Simmie.

MADRIGAL & CO.
Manila: 6th Floor, Madrigal Bldg., POB 1818. Pres.-Director: Simon R. Paterno.

MANILA MINING CORP.
Manila: 807 Zamora Bldg., Manila Hotel (Annex), Bonifacio Drive. Pres: Chas. A. Mitke.

MAREMCO MINERAL CORP.
Manila: Suite 406-A, AIU Bldg., 239 Juan Luna, Binondo. Pres: Jose Calderon.

MARINDUQUE IRON MINES
Manila: Pilot Bldg., Muelle de la Industria, POB 2292. Pres: Jesus S. Cabarrus.

PACIFICA, INC.
Manila: 944 Rizal Ave. Pres: Oliverio Laperal.

PHILEX OIL DEVELOPMENT
Manila: Rm. 508, Choy Bldg., Dasmariñas. Pres: Henry A. Brimo.

PHILIPPINE AMERICAN OIL DEV. CO.
Manila: 329 Madrigal Bldg., Escolta. Pres: Ernesto V. Lagdameo.

PHILIPPINE OIL DEV. CO.
Manila: Soriano Bldg., Plaza Cervantes. Pres: Andres Soriano.

REPUBLIC RESOURCES & DEV. CORP.
Manila: 7th Floor, Alliance Bldg., Binondo. Pres: Jose Tiong.

SAINT PHILOMENA OIL DEV. CO. (PHILDECO)
Manila: 190 Rodriguez Arias, San Miguel. Gen. Mgr: Enrique HR. Abila.

SAMAR MINING CO.
Manila: Pilot Bldg., Muelle de la Industria. Pres: Manuel Elizalde.

SAN JOSE OIL CO.
Manila: 419 Shurdut Bldg., Intramuros. Gen. Mgr: Theodoor Ranneft.

STANDARD-VACUUM OIL CO.
Manila: Standard-Vacuum Bldg., 1071 Isaac Peral, POB 436. Exploration Mgr: M. D. Williams.

TEXACO OVERSEAS PETROLEUM CO.
Manila: POB 1713, Shurdut Bldg., Intramuros. Supervisor: F. M. Ayers.

UNITED ASIA OIL & MINING DEV. CO.
Manila: Rm. 302-304, Alliance Bldg. Pres. & Director: Floro Crisologo.

WHITE EAGLE OVERSEAS OIL CO., INC.
Manila: Shurdut Building. VP & Treas.: E. Conrad Geeslin.

Supply and Service Companies

BERYLLIUM CORP. (copper safety tools)
Distributor: Yutivo Sons Hardware Company
Manila: Yutivo Building. Tel. 3-1481. Cable: YUTIVO. Chm: Yu Khe Thai.

CABEEN & ASSOCIATES, WM. ROSS (consulting geologists & engineers).
Manila: 601 Teodorica Apartments, 1148 Dewey Blvd. Cable: CABEEN. Mgr: Charles W. Allen.

CONTINENTAL-EMSCO CO. (drilling and producing equipment).
Distributor: Atlantic, Gulf & Pacific Co. of Manila.
Manila: Robert Dollar Bldg., Port Area, POB 626. Tel: 3-36-61. Cable: DREDGING. VP: Geo. Evans. Mgr: H. A. Clemente.

DRESSER MANUFACTURING DIVISION, Dresser Industries, Inc. (couplings, unions, ells, rings, weldments, pipe fittings)
Distributor: Getz Bros. & Company.
Manila: Pasong Tamo Ext. at Don Bosco Rd., Mikati, Rizal, POB 160. Tel: 50911. Cable: GETZ. Mgr: H. A. Palma.

DU PONT DE NEMOURS & CO., E. I. (tetraethyl lead, additives).
Distributor: Macondray & Company, Inc.
Manila: China Bank Bldg., POB 768. Tel: 3-98-91. Cable: MACONDRAY. Gen. Mgr: Newland Baldwin. Mgr. Chemical Dept: Dr. Barker H. Brown.

ELECTRO-TECHNICAL LABS. (logging equipment)
Distributor: Picspa Corp.
Manila: El Hogar Filipino Bldg., POB 610. Tel: 3-94-81. Cable: PICSPA. Mgr: L. R. Moran.

HUNTING SURVEYS, INC. (air survey and natural resources).
Distributor: Theo. Davies & Co. Far East Ltd.
Manila: Bonifacio Drive.

MARMON-HERRINGTON CO. INC. (all-wheel-drive kits for Ford and Mercury trucks).
Distributor: Manila Trading & Supply Co. (Ford)
Manila: Port Area, POB 744. Tel: 3-34-51. Mgr: J. L. Manning.
Distributor: G. A. Machmeries, Inc. (Mercury)
Manila: POB 3161. Cable: GANUM NABUKA. Mgr: Vincente A. Araneta.

MODERN ENGINEERING COMPANY (oxy-acetylene welding and cutting apparatus).
Distributor: Unico Trading Company, Inc.
Manila: 484 Rosario St., POB 2594. Tel: 2-52-65 and 2-78-07. Cable: UNICOTRA.

PHELPS DODGE COPPER PRODUCTS CORP. (building wires and cables for industry).
Manila: Soriano Building. Cable: PHELPDODGE. Mgr: Colonel Lee A. Telesco.

SANTA FE DRILLING CO. (drilling contractors).
Manila: POB 2367. Cable: SFEDRLCO - SANTIAGO (Isabela). Supt: J. D. Hunter.

TRACERLAB, INC. (radiation detection equipment, radioactive chemicals, nuclear instrumentation, consulting service, isotope applications).
Distributor: Modern Pharmacal Products Company.
Manila: 922-928 Rizal Ave.

TULSA WINCH, Division of Vickers (winches, power take-offs, speed reducers).
Distributor: U. S. Automotive Company, Inc.
Manila: Isaac Peral Corner, San Marcelino St.

UNITED GEOPHYSICAL CORP. (surveys).
Manila: 2504 Pennsylvania St., Apartment No. 303. Tel: 54029. Cable: UNITEDGEO. Mgr: Marshall D. Bradford.

HOW TO BE A MANAGER

Learn How to Make Decisions

Richard P. Barthol

"When the grasp on the bow was decision, arrow and hand and eye were one." — George Meredith

THE TITLE IS MISLEADING. You already know how to make decisions: if you have two or more alternate choices, you pick one. Perhaps, however, you are reading this article because you are dissatisfied with the way you make decisions and are interested in answers to questions like the following: How can I improve the quality of my decisions? How can I make faster decisions? How can I get others to accept the decisions I make? There are other questions, but we can lump them into three general categories:

1. *Difficulties that arise from the problem itself.*
2. *Difficulties that lie within the individual who is making the decision.*
3. *Difficulties in getting others to carry out the decisions.*

If we examine the first category, we can see immediately that decisions vary widely in complexity and importance. Throughout the day we are faced with an endless procession of unimportant decisions. Should I wear the brown striped tie or the tan striped tie? Should I have fried eggs or scrambled eggs? Should I take a coffee break now or finish this letter? Some people get bogged down with these decisions and go all to pieces when faced with anything more important than whether to have whole-wheat or white toast.

Chances are that you are not like that. If you were you would probably not be reading this article. You already know how to make unimportant decisions. But are you certain that all the decisions you labor over are important?

TIME IN DECISION-MAKING

Next time you are faced with a decision, consider what would happen if you made a mistake, that is, made the wrong decision. You may find that the advantages you get from making the best decision do not make up for the time and energy expended in determining the best course of action. If that is the situation, then clearly the most productive solution is to use intuition, a hunch, or the toss of a coin.

"It's them decisions . . ."

On the other hand, it might be clear that the decision is not unimportant. In that situation, you should seriously consider spending time on the problem.

There are many sayings about the effectiveness of time: "Time will tell"; "Time is a great healer"; "All in good time"; "Be ruled by time, the wisest counselor of all" and more. The implication seems to be that if we just sit around with folded hands, the passage of time will solve our problems. Actually, something of that sort seems to occur with many problems: if we leave them alone, they seem to solve themselves. But that in itself requires a decision, the decision being to do nothing about a particular problem. Furthermore, we cannot rely on that system for many solutions.

Time may place an even greater restriction upon the decision-making function whenever a decision must be made within a specified period — right now, within the hour, tomorrow, or next month. If we can identify that time period, we know much more about how we must make the decision. If time permits, we can defer making a decision until satisfied that we have all the information, advice, and thought necessary. If time is limited, then we must face the fact that we may have to make a decision based on the information at hand, with no possibility of getting more.

Most of us find ourselves in situations like that every day. Should the impending decision be an important one, the element of anxiety arises. The importance of the outcome clouds our thinking. Instead of concentrating on the possible courses of action, we become immobilized by our

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He was sent to Spain for six months in 1959 as adviser on industrial psychology and personnel management. Active in management training programs both University sponsored and as private consultant. Other private consulting on testing, selection, design of equipment, motivation, labor relations.

concern over the consequences of taking the wrong course.

The mature manager (or individual), after reducing the number of choices to a minimum, then makes the final determination by the best means available. If any one alternative is even slightly better than the others, then he takes that one. *Any* increase in the probabilities of success should be used, because in the long run it will pay off. Even an honestly run gambling establishment will make money since the probabilities favor the house. In roulette, for example, the odds of 38 to 36 are great enough to insure house success, even though the advantage is very slight.

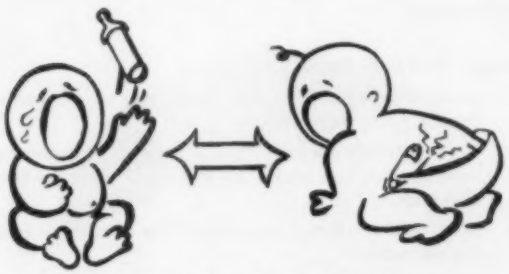
It does happen, though, that we sometimes cannot decide which alternative has the advantage. This situation is similar to the one in which the outcome was unimportant: in that instance it was not profitable to spend time and effort in determining the best decision; in this instance we are restricted by time or the nature of the problem, and cannot make a rational choice among alternatives.

Here the mature individual uses some non-rational means — intuition, the toss of a coin, or a personal though unrelated preference. And, more importantly, he can make his choice quickly, recognizing the difference between the problems involved in making a choice and the possible outcome of the choice.

Thus far we have considered some of the restrictions placed upon our decisions by the nature of the problem.

FIND THE PROBLEM FIRST

Let us look now at the other common occurrence: we have some alternative choices open to us, we have some time to consider these choices, and there is reason to believe that there will be some rational way of making the choice. There is a single rule that can guide you to increase your decision-making ability. If you follow the rule, you can increase your batting average by an unbelievable amount. The rule is easy to state and understand, but most people cannot seem to apply it. The rule is this: Do not look for solutions until you know what the problem is.



To find the solution first find the problem.

The first step of the so-called "scientific method," the backbone of the advances made by science, is "state the problem." A competent scientist may spend much more time trying to determine the exact nature of the problem facing him than collecting or analyzing data.

It was learned many years ago that an exact statement of the problem may in itself contain the answer, or may point the way to getting an answer. At worst, it will tell you what else you must know in order to arrive at a solution or that there is no solution to the problem. Most of us, when faced with a problem, attempt to think up solutions. More often than not our solutions are not productive because they solve the wrong problem. We may be attacking symptoms rather than causes.

Let us look at a fairly common example from industry. An executive received a regular monthly personnel report and discovered that there had been an increase in tardiness. Being a man of quick decision he identified the problem as "How can I stop workers from coming in late?" Once the problem is stated like that he must inevitably arrive at a decision to discipline any worker who comes to work late.

The executive decided that any worker who came late would lose a full hour's wage for any portion of a clock hour missed. The number of tardy workers decreased, but those who were late tended to miss almost the full hour. Furthermore, overall production decreased in the organization. He had stated the wrong problem. There were several problems he should have looked at.

The first would be something like "What is the effect on the organization of tardiness?" Surprising though it may be to many managers, it is possible that tardiness might not be harmful; on the contrary it could be a healthy sign. Normally we would expect to find negative effects, so the next question might be "Why do some workers come to work late?"

That question leads to a totally different set of behaviors. The executive would not yet make a decision; he would gather more data. Once that information was obtained, he might ask "What can be done to eliminate the things that cause workers to come late?", "What can be done that will motivate workers to come on time?", and "What will be the effect of instituting any of these measures?"

Those are not necessarily the best statements of his problem, since each organization will have slightly different conditions. He might have asked "Why am I so concerned about having people come on time?" or "How can we increase production?" But however it is phrased, the question that is asked will determine the kind of answer that is found. The worth of a decision is determined more by the way you state the problem than by the information you get.

It should not be assumed that stating the problem accurately is a short cut or that it is easy. It is more difficult to state a problem than it is to decide on a solution.

REMEMBER YOU ARE THE DECIDER

The second thing we should look at in the decision-making function is the person who makes the decision. In this instance, the person is you. Most of us do not use our good qualities to the maximum, but tend to drift along following the habits developed throughout our lives. It is possible to learn much more about the way we behave, if we want to take the trouble. We can learn every day by the simple process of observing with an open mind. We can listen to what other people say and see how they behave toward us and at least find out how we appear to others. You may find strengths and weaknesses that you did not know you had, and you might be quite startled by what you find out. Here are two examples, one positive and one negative, that are fairly typical.

A man with only a high school education felt that his co-workers with college educations looked down on him and also that he did not speak with as much fluency as others. Neither was true. Most people are not aware of the extent of the educational background of others, and the ability to speak clearly and sensibly is not related to amount of education. Consider such self-taught people as Abraham Lincoln and William Shakespeare; compare them with some college graduates you have known.

The man I am describing (actually there were many just like him) took much convincing before he could accept the fact that his colleagues respected him and felt that he spoke very well. The interesting thing is that he was disturbed at finding that he was better than he thought he was, much as he would have been had he discovered something negative about himself. We all tend to hold on to our self-concepts, whether they be good or bad.

The second example is even more common. This man

thought he was tolerant, open-minded, and based his decisions on logic rather than prejudice and emotion. It was clear to everyone else that he was just the opposite. He, too, eventually saw the light and was able to make allowances for his biases. Note that I do not say that he overcame them. He was able to accept the fact that he had such feelings and could sometimes adjust his thinking by recognizing those areas that he knew would cause him trouble.

He was greatly disturbed at his discovery that others saw him differently from the way he saw himself, but it made him a more productive manager. Have you ever said "I am not prejudiced against X's (any group). Why, some of my best friends are X's." What do you think of the idea that you probably are very much prejudiced against that X group? The probabilities are high that you are.

Admittedly we cannot cover a project like this in a way that would apply to all readers, but we can make a general statement that might be of some value: Since you are a human being, you will bring to any decision your own unique experiences, personality, intelligence, etc., and the decision you make will be based partly on the "facts" of the case, and partly on who you are. If you know more about yourself, you might be able to improve your decisions.

OTHER PEOPLE INVOLVED

The third factor in decision-making is the receiver, that is, the other person affected by your decision. Since we are concerned with management, the decisions we are discussing almost always affect others, usually subordinates.

One of our major problems is to get others to accept our decisions with enthusiasm. It is well known that almost everyone is happier with those decisions he makes himself than with those forced upon him by others. If you have any doubt about it, look at your own experience. If you have hunted, fished, played football, or climbed mountains, you know that you have willingly undergone a great deal of physical discomfort that would have made you quite unhappy had you been forced to do it. It follows, both logically and from experience, that subordinates work with more enthusiasm when they have something to say about their destiny. In spite of that, most managers retain as much of the decision-making function as possible and yet wonder why there is so much resistance to their sound directives.

Managers believe they must make so many decisions in order to insure having the right ones made. Actually they are usually simply responding to their own personal needs and not the needs of the organization. We might say that they are more concerned with being managers than they are in seeing that the organization is managed properly. Most of the decisions made at any given level could have been made at a lower level faster and better, and there would have been no resistance to carrying out the decision.

Professor Norman R. F. Maier has written a book, *Principles of Human Relations*, that describes these ideas very well. The general principle is that all decisions should be made as far down the organization as is possible — and that is much farther down than most managers believe. When in doubt, let your subordinates make the decision.

Some decisions are best made by the subordinate.

IN A NUTSHELL

The apparently simple task of making a decision, that is, choosing one alternative out of several, is complicated by three factors: the nature of the problem, the person who is to make the decision, and the difficulty in getting subordinates to accept the decision willingly. We can simplify our decisions by learning to recognize: (1) those decisions whose outcomes are not important and (2) those which because of lack of time or the impossibility of getting adequate information cannot be solved in a rational manner. These decisions can be quickly made by flipping a coin, following a hunch, or using some unrelated preference.

The large number of the remaining decisions can best be attacked by first carefully determining the exact nature of the problem. This, the first and most important step of the scientific method, will enormously increase the probability of making wise decisions.

As long as decisions are made by human beings, the psychological make-up of the individual is a critical factor. If you want to improve your decision-making, you must try to learn more about the way you behave. Although this is not an easy task, you can make an effective start on it by trying to observe how other people act toward you and what they say to and about you. You can get a lot of information if you are not afraid to accept things, both good and bad, that you had not known about yourself.

Finally, the problem of getting subordinates to accept decisions that affect them can be greatly reduced by allowing them to make or participate in as many decisions as is possible. Although most executives cannot accept the idea, it seems quite clear that decisions are made in the upper echelons, not because it is the best management technique, but because it meets the personal needs of the executive to feel important.

Check Yourself Here

1. Under what conditions should you rely on a hunch or chance for a decision?
2. In what different ways does *time* affect our decisions?
3. How can you use *probabilities* to improve your decision-making?
4. What is the first and most important rule about making decisions?
5. What can you do about yourself as a decision-maker? Do you really believe you have an open mind?
6. Where does the author think decisions should be made in an organization? How can you reconcile that idea with the concept of responsibility? If you disagree with the author, is it because of the reasons you give, or is it because you have the kinds of needs that the author suggests?

These Books Give More Ideas and Details

[1]*Maier, Norman R. F., Principles of Human Relations, John Wiley & Sons, New York, 1952*

[2]*Haire, Mason, Psychology in Management, McGraw-Hill, New York, 1956*

[3]*Hoslett, Schuyler D., Human Factors in Management, Harper & Brothers, New York, 1946*

[4]*Bass, Bernard M., Leadership, Psychology, and Organizational Behavior, Harper & Brothers, New York, 1960*

WHAT TO DO ABOUT FACTIONS

If you have cliques in your company or department, they must be controlled or they can ruin you . . . Here are possible moves for settling or directing factionalism

KENT WILLIAMS

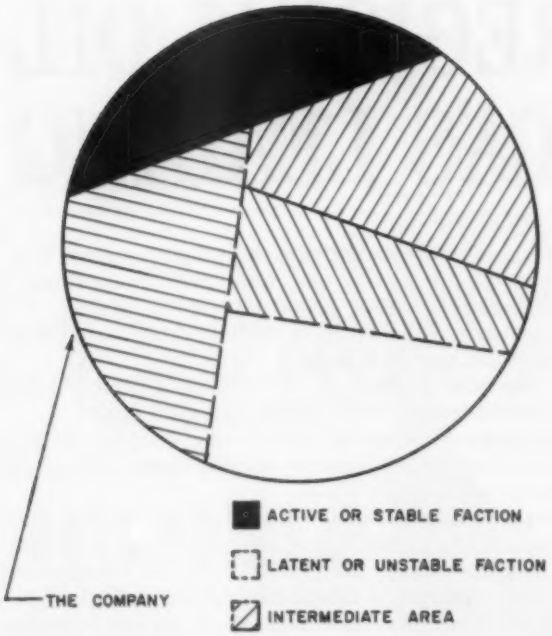


FIG. 1.

FACTIONS ARE NATURAL and normal — they are found in virtually every company. Factionalism can be either beneficial or detrimental to an organization, depending upon the degree to which it is recognized and controlled by management. What, then, is a realistic and constructive attitude for the administrator to cultivate with regard to the problem of factions and their control?

Webster defines a faction as "a party, combination, or clique within a state, government, party, or other association — generally with the suggestion of contentiousness, self-seeking, or recklessness of the common good."[1] This definition is satisfactory, as far as it goes. However, a further distinction is to be made between "stable" or "active" factions and "unstable" or "latent" factions.

Stable factions are those which are more or less sharply defined; whereas latent factions may be thought of as factions which actually do exist but which are dormant and/or non-aggressive. Fig. 1 illustrates stable and unstable factions as they may develop within virtually any organization, whether it be a company, religious body, government, social club, etc.

Factionalism is one of the most common problems of industrial management, and handling it is apt to be a very delicate matter. Here are some possible courses of action.

One possibility is to learn to live with the factions — let the company organization adjust itself to them as they grow and develop. In other words, management might adopt the policy of essentially doing nothing about factionalism. The problem involved here, of course, is that the internal strife generated by the opposing parties may have a crippling effect on a company. This is highly undesirable at best, and may even be disastrous — particularly in a highly competitive industry.

A small but promising Midwestern manufacturing concern recently went out of business as a direct result of a factional dispute which originated when the president's wife expressed dislike for the wife of one of the major stockholders. One thing led to another over a period of time until, finally, the effective operation of the company was impaired.

It is far better for an organization to turn factional energy to its benefit, rather than letting the effectiveness of the company be dissipated by factional strife. Carrying this one step further, it follows that an important aspect of the administrator's job is either to prevent the development of factionalism or, failing in this, to channel factional energy along productive lines. In other words, the *control* of factionalism is a problem which may be every bit as important to management as the *prevention* or *elimination* of factionalism.

A second alternative for combatting factions is to "stamp them out." This type of activity can take the following two forms: (1) elimination of all factions and (2) removal of all factions except one. Obviously, either of these methods, if carried out, will accomplish the objective of eliminating conflicts, since it takes two (or more) to make an argument. Of course, once it has been decided which factions are to be stamped out, the problem remains of just how the job is to be accomplished — especially when large groups of personnel are involved. It is probably safe to state that the answer to this question is yet to be discovered.

Another possible method for dealing with factions is to disperse them by firing or transferring the individuals involved. This ties in somewhat with the alternative just discussed. This method is quite difficult to implement, if more than a few people are affected. For example, the organization of professional employees into unions that engage in collective bargaining activities is a case of factionalism. Most companies can scarcely afford to fire large numbers

[1] Webster's New Collegiate Dictionary, Second Edition. Springfield Massachusetts: G. and C. Merriam Co., 1953. Page 296.

5 LEADING REGIONAL OIL AMERICA'S LEADING

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THE AUTHOR

KENT WILLIAMS, *an engineer in Long Range Planning for Standard Oil Company of Ohio, has a BS in chemical engineering from Carnegie Institute of Technology, an AB degree from Baldwin Wallace College and in 1959 received an MS degree in Industrial Management from Purdue University. He has had some experience in Sohio's Process and Product Development Division. In this article he deals competently with a difficult subject, cliques or factions, a problem which can easily hinder a company's progress.*

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of professional employees, thus throwing away a large recruiting and training investment. On the other hand, nothing will be accomplished in this instance by merely transferring people since they would retain their union membership. This may be somewhat of an extreme case, but it is representative of a type of factionalism which is very difficult to deal with, and which is apparently becoming more prevalent as time goes on.

A fourth possible method for handling factions is the strategy of removing the leader(s) of the movement through promotion, transfer or firing. This course of action is obviously based upon the theory that a leaderless faction will either die out completely, or at least subside into a latent state. An important advantage of this method is the fact that it eliminates the necessity of dealing with a large number of individuals.

A problem arises, however, because it is not always possible to fix the identity of the faction leader(s). Also, not only does the administrator have to know whom is to be dealt with — he must also generally have a tangible reason to offer for promoting, firing or transferring a man. Management cannot merely say, "We're promoting Joe Doakes because he's been heading up a faction around here."

A compromise between conflicting factions is always a possible solution. This is a commonly accepted means of resolving differences — it has been the basis of trade union tactics for many years. However, compromise means that all sides must yield somewhat — the result frequently being that no one is really happy or satisfied.

Another means for settling factional conflicts is the practice of "integration" as suggested by Follett.[2] Integration may be defined as a decision or action which unites the desires of all of the conflicting factions, requiring no one to give up anything. The following quotation of a business executive is an example of integration as applied to resolving a dispute:

> *"Our paper had been selling at 6¢ and the competing firm reduced their price to 5¾¢. We cut to 5½¢ and they replied with a price of 5¼¢. The question before us then was whether or not to reduce price further. Part were in favor, part against. The solution came when something quite different was suggested: That we should make a higher quality paper and charge an appropriate price for it."*[2]

A possible function of the administrator, then is to serve as an integrator of the interests of all parties concerned.

The alternatives discussed up to this point have all dealt with means of combatting factions which already exist, and have grown to the point where they must be reckoned with. This is a realistic approach since, in a large number of cases, factionalism is far advanced before it is discovered.

Factions are much easier to control if they are recognized in their earlier stages of development.

For example, suppose an employee begins to complain and/or set forth some more or less radical proposal. It appears that he might be convincing other employees and starting to build up a following. The alert administrator should be on the lookout for such signs of possible developing factionalism. Quite often a good approach in such a situation is to give the instigator some additional responsibility — make him chairman of a committee to investigate this problem which he has called attention to, or assign him to check into the matter on his own. In a surprising number of cases, such a strategy will result in the subject being dropped and allowed to die out — the leader is afraid to accept responsibility for his actions, or decides that the whole business is not worth bothering about after all.

On the other hand, if the matter is pursued further, then the administrator will be in a position to keep an eye on developments and perhaps guide and channel the movement along constructive or productive lines.

Proper handling of complaints will help avoid development of factions. If the complainant who feels that he has not received satisfaction talks among his fellow employees, he may create distrust and poor morale.

A good example of this occurred a few years ago in an industrial plant. The plant had no personnel manager. Thus complaints had to be handled by top management.

Although the management had always tried to maintain an "open door" policy, they were so busy that complaints were occasionally neglected for a period of time. As complaints piled up, the dissatisfaction among the men in the shop increased despite their feeling, developed over the years, that management had always been fair and sympathetic. Finally, all three shifts went on strike — chiefly because a single employee had been unable to obtain adjustment of a grievance.[3] Prompt attention to his complaint would have prevented such a situation from becoming serious.

In summary, then, the following seven strategies have been suggested as a means for combatting factions:

1. *Learn to live with them.*
2. *"Stamp them out."*
3. *Disperse them by firing or transferring the group members.*
4. *Promote, transfer or fire the leader(s).*
5. *Compromise the conflicting positions.*
6. *Integrate the various factional interests.*
7. *"Nip them in the bud."*

The decision as to which of the above method or combination of methods is to be applied will depend upon the circumstances of the particular situation, such as the size of the company, the seriousness of the issue at stake, the number of individuals involved and their status within the company, the extent to which the factional movement has become firmly established, etc.

Remember that there are bound to be some misunderstandings, irritations and frustrations develop within a company. Conflict is unavoidable and is here to stay. Since we cannot avoid it, we should use it — set it to work for us as the engineer often employs friction. In many cases, it would be desirable to eliminate friction, but we also employ it to good advantage in driving belts and pulleys, in friction clutches and brakes, etc. In fact, some conflict may actually be desirable, since it forces troublesome issues into the open where they may be resolved.

Therefore, a good general rule to follow is this: Avoid "riding herd" on factional movements if possible. But be on the lookout for signs of developing factions so that they can be recognized at an early stage and their activity properly channeled. ★ ★ ★

[2] Follett, Mary P., Creative Experience, Longmans, Green & Co., New York, 1924. Page 158.

[3] Busch, Henry M., Conference Methods In Industry, Harper & Brothers, 1949. Page 68.

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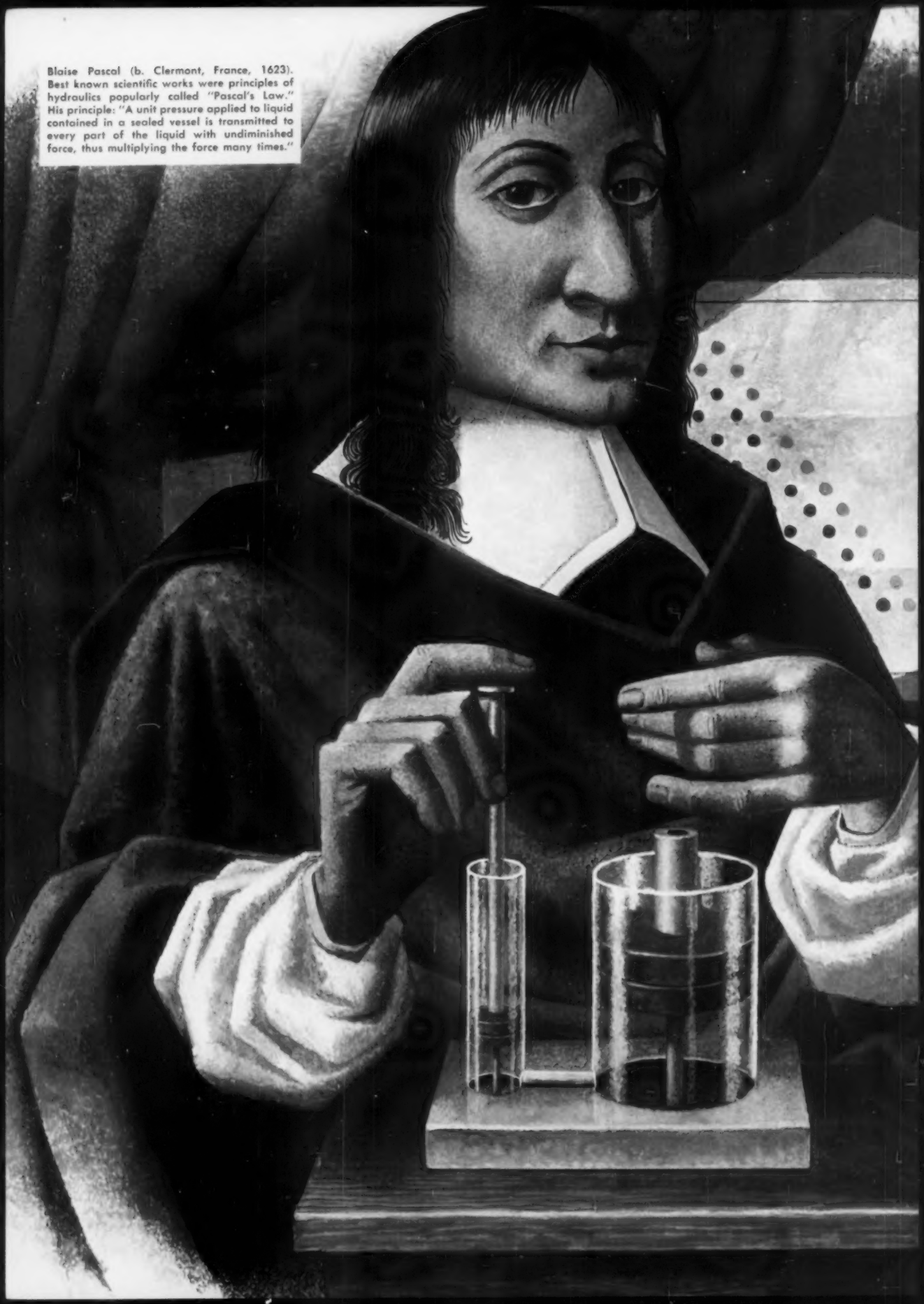
Blaise Pascal (b. Clermont, France, 1623). Best known scientific works were principles of hydraulics popularly called "Pascal's Law." His principle: "A unit pressure applied to liquid contained in a sealed vessel is transmitted to every part of the liquid with undiminished force, thus multiplying the force many times."

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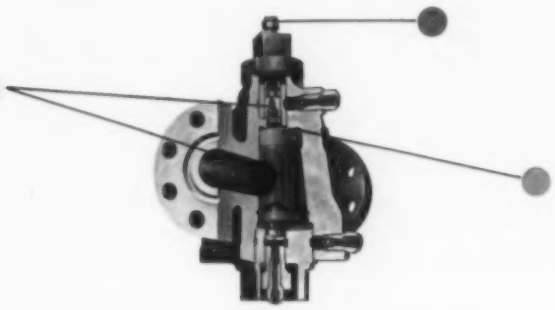

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NEWS ON TEXACO PROGRESS

A long way from curb service a la cart

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PEOPLE RECEIVED MORE MONEY

An omitted footnote in the table "People in Petroleum" (July, 1960, page E-5) showed benefits only for a half dozen companies instead of payrolls and benefits. Some figures were revised and the footnote is published for others in the table below. If you keep these data, please clip this and paste it over the one already published. The figures give average employee's payrolls and benefits about $6832 in 1959 compared to $6460 in 1958.

PEOPLE IN PETROLEUM

Company	Holders of common stock		Employees, average		Payrolls & benefits ($1000)	
	1958	1959	1958	1959	1958	1959
American-Petrofina	—	—	1,150	1,175	—	—
Ambassador Oil	485	3,163	148	168	1,185	1,231
Anderson-Prichard	7,000	7,735	917	910[1]	6,534	6,596
Argo Oil Corp.	5,192	5,453	182	185	—	—
Ashland O. & Ref.	38,766	41,944	4,600	4,600	3,778*	3,970*
Atlantic Ref. Co.	51,923	53,149	16,247	15,394	112,747[2]	112,680[2]
Aztec O. & G.	7,989	9,214	36	47	—	—
Blackwell O. & G.	673	743	55	60	—	—
British American	34,975	34,967	7,660	7,450	46,000	47,400
Champlin O. & Ref.	18,290	19,608	1,503	1,536	1,714*	1,779*
Cities Service Co.	173,000	172,000	18,700	18,000	—	—
Clark O. & Ref.	—	—	2,500	2,880	—	—
Coastal States	2,600	3,400	141	201	447	682
Colorado O. & G.	7,097	7,103	1,330	1,400	4,626	6,896
Continental Oil	31,017	37,550	11,117	11,333	75,478	80,399
Cosden Petroleum	8,000	11,000	950	1,070	6,138	6,496
Delhi Taylor	12,000	15,000	659	681	4,735	5,210
Drilling & Exploration	2,300	2,400	363	337	2,856	2,800
Eason Oil Co.	516	502	131	125	566	587
Frontier Ref. Co.	1,798	1,851	616	505	—	—
General American	4,591	4,553	532	503	3,032	3,000
General Crude	1,143	1,156	212	209	1,566	1,589
Getty Oil Co.	13,485	14,348	532	588	—	—
Gulf Oil Corp.	93,580	100,805	56,000	50,700	312,752	302,447
Helmerich & Payne	3,500	3,700	625	514	2,953	3,202
Honolulu Oil Corp.	4,711	5,505	667	730	5,407	6,223
Hugoton Prod.	5,100	4,850	75	75	—	—
Husky Oil Co.	2,923	4,500	788	725	4,038	4,284
Intex Oil Co.	1,071	980	85	78	708	697
Kendall Ref.	2,709	2,772	685	658	3,774	3,840
Kerr-McGee	5,736	5,890	2,981	3,411	17,753	18,399
Leonard Ref.	4,497	4,500	676	656	4,839	5,005
Louisiana Ld. & Exp.	9,751	9,678	115	115	1,010	1,053
Macmillan Petroleum	1,832	1,468	295	248	—	—
Midwest Oil	7,353	7,128	127	135	—	—
Monterey Oil	4,609	4,600	382	403	3,159	3,232
Murphy Corp.	1,350	1,370	632	808	3,671	4,423
Ocean Drilling & Exp.	943	950	278	270	1,565	1,378
Ohio Oil Co.	43,514	43,769	6,453	7,534	44,707	55,970
Phillips Petroleum	127,749	135,523	24,459	24,575	182,788	190,558
Plymouth Oil Co.	8,676	9,058	938	927	7,596	7,356
Producing Properties	2,027	4,625	114	176	751	1,316
The Pure Oil	46,078	47,711	10,981	10,740	73,064	74,939
Quaker State	6,502	6,392	1,398[1]	1,448[1]	7,397	7,954
Republic Natural	5,100	5,000	314	307	2,310	2,332
Richfield Oil	11,783	12,204	6,260	6,374	43,694	46,808
Shamrock O & G.	6,735	6,941	962	990	6,400	6,700
Shell Oil	19,307	19,730	38,572	38,217	325,352	341,567
Signal O & G	10,760	13,381	1,691	3,176	12,211	16,149
Sinclair Oil Corp.	116,165	119,802	23,828	23,557	165,002	168,332
Skelly Oil	5,857	6,167	4,817	4,787	31,173	32,262
Socony Mobil	207,000	224,000	43,700[2]	40,900[2]	357,100[2]	354,200[2]
South Penn	10,459	11,047	2,323	2,341	12,456	13,317
Standard Oil Calif.	152,754	159,707	38,395	38,390	280,624	299,543
Standard Oil Indiana	151,937	158,553	46,033	43,569	352,469	348,411
Standard Oil N. J.	503,000	582,000	154,000	146,000	953,000	969,000
Standard Oil (Ohio)	37,535	37,915	11,138	10,690	77,917	80,254
Sun Oil Co.	25,954	27,375	17,521[4]	17,292[4]	121,721	128,149
Sunray Mid-Continent	105,575	110,590	5,599	5,894	36,653	41,688
Texaco Inc.	138,380	143,344	54,999	53,956	328,386	341,514
Texas Pacific	5,402	5,765	474[1]	449[1]	3,367	3,496
Three States	12,000	12,500	103	98	671	668
Tidewater	20,911	23,589	9,459	9,361	62,297	64,098
TXL Oil Corp.	8,100	8,900	68	79	—	—
Union Oil of Calif.	51,700	50,400	7,873	7,846	60,925	64,933
Union O & G of La.	1,352	2,163	418	425	—	—
Universal Consol.	2,900	3,400	83	76	791	725
Wilcox Oil & Gas	2,022	2,000	122	115	798	764
TOTAL	2,433,439	2,599,086	647,787	629,172	4,184,652	4,298,501

*Benefits only. [1]At year end. [2]Payroll only. [3]U. S. only. [4]Oil Division.

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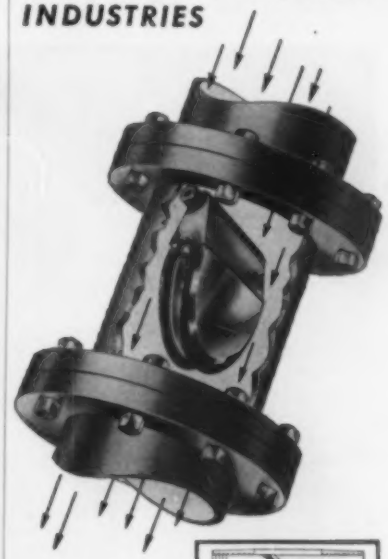

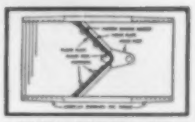

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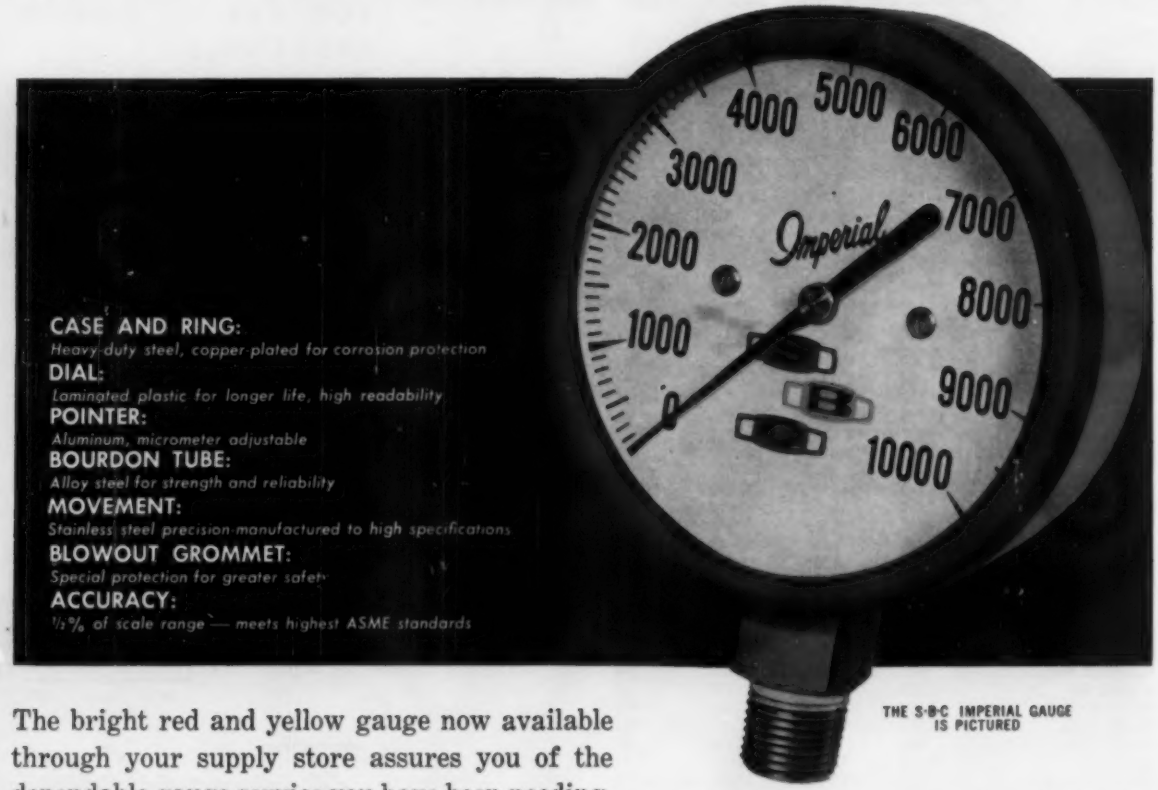

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Books To Read . . .

The Executive Interview, *by Benjamin Balinsky and Ruth Burger. Published by Harper & Brothers, 49 East 33rd Street, New York 16. 198 pages. Price, $4.*

Based on tested psychological principles, but free of technical jargon, this handbook is designed exclusively for the executive who is called upon to talk with people both formally and informally during his work day. It reviews for the manager, the supervisor, and the student of management the best techniques in a wide range of interview situations.

Separate chapters are devoted to the elements which make for successful interviewing, such as breaking down the barriers to communication and establishing rapport. Then specific interview situations are covered, including employee selection, handling personnel conflicts, personal counseling, helping the individual to realize his greatest potentialities within the job situation, and dealing with the employee under tension. Each is discussed in detail with sample dialogues to illustrate specific points. There are also separate chapters on the art of asking questions and the role of listening.

"1959 Economic Survey of Europe," *a United Nations publication, New York. Price, $3.00.*

This survey is the thirteenth in a series of reports prepared by the Economic Commission for Europe. The first part is devoted to an analysis of developments in European economy and prospects for economic growth. This includes material on the economies of eastern Europe and the Soviet Union.

There is a large section full of long-time plans for the Soviet Union and its satellites. You can get table after table of percentages with very few actual figures to build on. As the secretariat states, he has been assisted by materials supplied by governments for this economic record.

Management Creeds and Philosophies, *by Stewart Thompson. Published by American Management Association, Inc., 1515 Broadway, New York 36, New York. Pages, 127. Price $3. AMA members $2.*

This study was undertaken to obtain a picture of actual industry usage and results of management creeds. The author says "It is the reaction of some that philosophies are more appropriately considered and discussed in academic and religious circles than in practical management. This hardly can be supported when it is realized that a philosophy is a basic attitude. It is a frame of mind. It is a guiding principle and should be a deep conviction. The effectiveness of the application of the principles of management . . . is largely dependent upon what is in the minds of those who apply them."

The appendix includes the creeds of a number of businesses. Here are the "Six Basic Principles" in General Motors' creed:

1. *Put the right people in the right places.*
2. *Train everyone for the job to be done.*
3. *Make the organization a coordinated team.*
4. *Supply the right tools and the right conditions.*
5. *Give security with opportunity, incentive, recognition.*
6. *Look ahead, plan ahead . . . for more and better things.*

"A Century of Oil and Gas in Books," *a descriptive bibliography, compiled by E. B. Swanson. Published by Appleton-Century-Crofts, Inc., 35 West 32nd Street, New York 1, N. Y. 230 pages. Price, $4.75.*

This is a descriptive bibliography compiled by E. B. Swanson who was in the Civil Service until his retirement in 1954. He headed the first Division of Petroleum Economics of the United States Department of the Interior. The API sponsored the publication of the bibliography, which includes all items published commercially or privately in English, having to do directly or essentially with some aspect of petroleum. Over 2000 items are cited by the author, and in each case the title, author, publisher, city of publication, rate, number of pages and brief report is given. There is also an index. No fiction is included.

Mr. Swanson is considered a leading authority on books dealing with petroleum. His first collection was purchased by the government of Venezuela and his second group of books on petroleum was collected by the Interior Department with financial assistance from friends in the petroleum industry.

Petroleum Sourcebook, *1959 edition, published by National Petroleum Bibliography, Box 3586, Amarillo, Texas. Price $7.50.*

A worldwide directory of information sources classified by country, region, and state or province, the 234-page book lists the 1958 references to petroleum literature from the trade press, as well as publications of professional societies, state and federal agencies, and mapping, statistical and financial institutions. More than 5000 references are compiled from approximately 1500 publications.

Designed to serve as a desktop information service, the book has been widely accepted as a basic reference, copies sold in 54 countries last year. It may be ordered direct from the publisher, on approval if desired.

Technical Communication, *by George Harwell. Published by The Macmillan Company, 60 Fifth Avenue, New York 11, New York. 318 pages. Price, $5.*

An associate professor of speech at Duke University, George Harwell, wrote this text book primarily with the engineering student in mind, but so many engineers and scientists are still students in writing, so this simple and direct explanation of how to write well will be useful to almost any reader.

The book has three motifs: First, an immediate and continuous effort to show what good writing really is. In this phase, the author makes a statement that should be stressed. He says that whether the field is technical or not the basic elements of good writing are always the same. They do not vary according to the subject matter. Many technical writers have the idea that you can only be stiff and prosaic and dull in presenting a scientific theme. This false impression needs to be cleared away.

Second, the book presents an approach that is consistent because it stresses underlying principles instead of many surface practices. And third, the volume has models that are uniform in mechanics and uncomplicated in subject matter. A book like this is good reference even though you don't sit down and read it through. When you are debating how to attack a problem in communications, you can generally find some helpful guidance in a volume of this kind.

Mining Developments in Asia and the Far East 1957, *published by United Nations, Columbia University Press is the official distribution agent in the United States. Price 75¢.*

Petroleum (and natural gas) is only one of the seven divisions covered. Others are ores, metals, etc. Data for the report have been obtained mostly from governments and government agencies. Although it is understandable that it takes time to make accurate collections of this type of information, we can still regret that this is for 1957 which makes it less valuable to most readers. For those who search for oil in the Far East, however, this reference on all types of mining may be valuable because some petroleum companies have mining leases.

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October is Gasoline Tax Reminder Month!

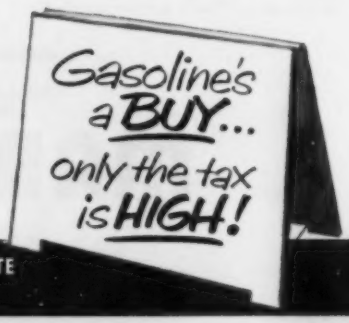
It's the anniversary of the latest temporary Federal gasoline tax increase!

Every oil man and woman should be keenly aware that October is gasoline tax reminder month. October 1, 1959, was the day the temporary 1¢ increase in the Federal gasoline tax went into effect, making the total Federal tax 4¢ a gallon. That's why October is an excellent time for you to remind your friends and business associates about high gasoline taxes. And make sure they know that Congress promised this temporary tax increase would expire on June 30th, 1961 . . . and the Federal tax revert to 3¢ a gallon.

Here are the facts about high gasoline taxes that everyone should know:

- **Motorists pay about one dollar in taxes on every ten gallons of gasoline they buy!**
- **The gasoline tax rate is five times as high as the tax on luxuries like diamonds and mink coats!**
- **Motorists now pay about a 50% sales tax on gasoline!**

So, take advantage of this special gasoline tax reminder month and give your friends the facts about high gasoline taxes.



COMMITTEE ON PUBLIC AFFAIRS OF THE AMERICAN PETROLEUM INSTITUTE
1271 AVENUE OF THE AMERICAS, NEW YORK 20, NEW YORK

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

ALLEN-BRADLEY

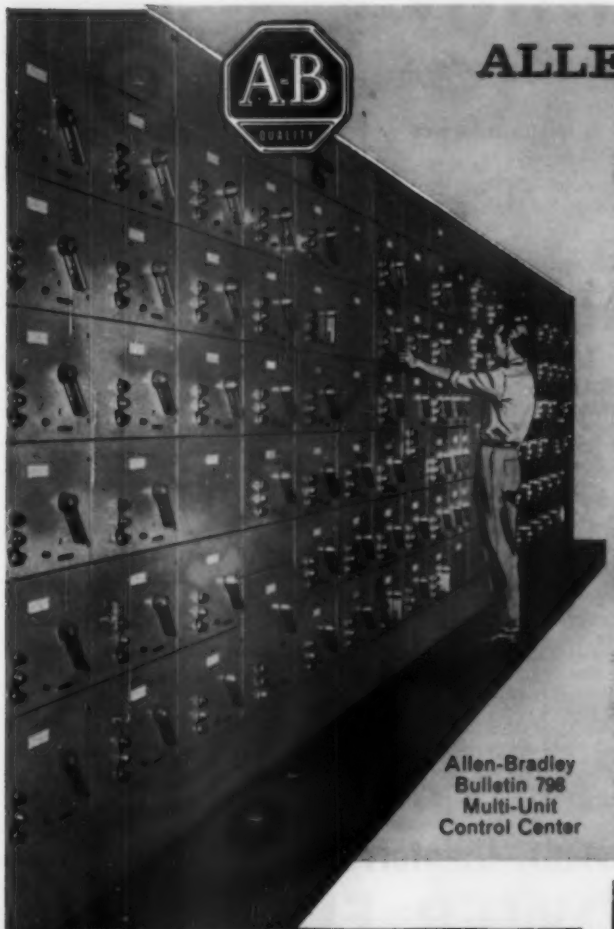
Quality Control Centers

...the mark of a modern plant providing the utmost in reliability, safety, convenience, and lasting beauty

The superior *quality* of Allen-Bradley control centers provides a modern and attractive installation—one that you'll be justly proud to have in your plant. The cost is commensurate with the quality of the workmanship—but you'll never have reason to regret your decision. Furthermore, Allen-Bradley control centers arrive completely wired and tested—and *installed* costs are usually substantially lower than that of individual starters.

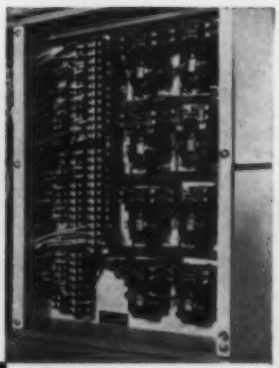
The flexibility of A-B control centers makes them readily adaptable to changing needs. Individual units can be added or modified without internal rewiring. In addition, entire sections can be added to meet future plant expansion.

For the finest in control centers, you cannot surpass Allen-Bradley's Bulletin 798. Write today.



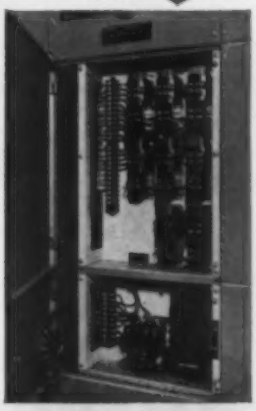
Allen-Bradley Bulletin 798 Multi-Unit Control Center

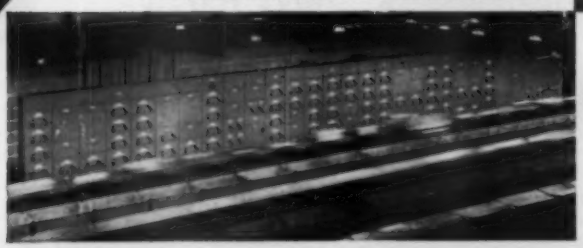
This shows A-B control center unit with popular A-B Bulletin 709 solenoid starter and circuit breaker.



This shows A-B Bulletin 700 control relays mounted in an A-B control center unit.

A-B control centers can be equipped with a wide variety of components. These Bulletin 849 timers are used on an automatic conveyor line.





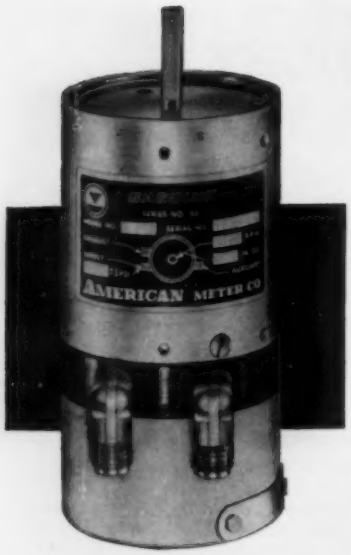
This huge, 48-foot A-B control center houses 101 A-B Bulletin 709 solenoid motor starters. It is designed to permit an addition containing 50 more Bulletin 709 starters.

ALLEN-BRADLEY

Member of NEMA

Allen-Bradley Co., 314 W. Greenfield Ave., Milwaukee 4, Wis. • In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

QUALITY MOTOR CONTROL



AMERICAN®

GASCLOK

POWER

DRIVE

Completely self-contained gas or air-powered instrument driving and timing unit for long, trouble-free operation in remote locations. The GASCLOK delivers more than 20 times the torque of conventional spring-wound mechanisms. Continuous timing accuracy is unaffected by a ± 20% variation in supply pressure.

Inherently explosion proof and self-starting, the GASCLOK is ideal as original or replacement equipment for strip chart and conventional circular chart instruments. The timing mechanism is internally sealed to prevent corrosion, and all power unit parts exposed to gas are aluminum or stainless steel. Large area internal ports prevent clogging. Normal air or gas consumption 5 cfh . . . operating pressure 5 psi . . . rotation 2 rpm.

AMERICAN®
METER COMPANY
INCORPORATED (ESTABLISHED 1836)

Executive Offices: Philadelphia 16, Pa.
Sales offices in principal cities.

Laugh with Barney

"Jones is the most brutally frank business man in town."

"How so?"

"When he remits in payment he writes: You have already found the enclosed check."

* * *

The only reason a great many American families don't own an elephant is that they have never been offered an elephant for a dollar down and easy weekly payments.

* * *

A teacher in an Oklahoma school asked if any of her pupils were part Indian. "I am, teacher," replied Tommy.

"What tribe, Tommy?"

"Well, I don't think it was exactly a tribe," explained Tommy. "It was just a wandering Indian."

* * *

A young lady was spending the weekend with a straight-laced country family in South Carolina. Fearing the pajamas she wore instead of a night gown might be considered improper, she carefully hid them each morning. But one day at breakfast she realized she had forgotten and left them on her bed. Excusing herself, she rushed upstairs. The pajamas were gone.

While she hunted for them, a maid appeared at the door. "If it's the pajamas you're looking for, Miss," she said, "I put them back in the young gentleman's room."

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Trainee for leading oil, gas, petro/chem publications. Must be personable, intelligent, tactfully aggressive. He could be a graduate in advertising, marketing, journalism, or a petroleum, mechanical or chemical engineer presently employed in the oil-gas industry. Writing aptitude important. Excellent opportunity for young man of right qualifications. *Apply by letter and resume to* **P. O. Box 1589, Dallas, Texas,** *sending qualifications, telephone number and photo. Replies will be held in confidence.*

EQUIPMENT FOR SALE

TD-9 with Superior sideboom and backfill blade, new condition. J. E. Atkinson, Telephone—LO6-4220, Fort Lauderdale, Fla.

EMPLOYMENT WANTED

Gas Processing Superintendent wants employment with progressive independent oil company. 20 years' experience in measurement, gathering, compression, processing, dehydration and sale of natural gas as well as in preventative maintenance and plant construction. Box 227, The Petroleum Engineer, P. O. Box 1589, Dallas, Texas.

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BALL BEARING MOTORS

Here's Why . . .

They are specifically designed to overcome the unusual conditions of Oil Field requirements, and there is a type and H.P. built to fit your exact needs. Unexcelled since they are . . .

- **DRIP PROOF**
- **VERMIN PROOF**
- **MOISTURE PROOF**
- **CORROSION RESISTANT**
- **FORCED AIR COOLED**
- **HAVE SEALED TERMINAL PORT**

SEMI-ENCLOSED — normal or medium slip, 3 phase, 60 cycle. Has prelubricated ball bearings in semi-enclosed protected housing, 40 degree C rise. Built for continuous duty. **High Torque, low starting** current. Extra insulating coating throughout.

TOTALLY ENCLOSED — Fan cooled, normal or medium slip, 3 phase, 60 cycle. Has prelubricated ball bearings, totally enclosed FAN cooled 55 degrees C rise, for continuous duty. High Torque — low starting current. Extra insulating coating throughout.

Write for fully descriptive literature

BETHLEHEM STEEL CO. Supply Division **Tulsa, Oklahoma**

Manufactured by Valley Electric Corporation, St. Louis 8, Mo.

Management Personals

Marion J. Epley Jr., formerly vice president and assistant to the chairman of the board, is new senior vice president in charge of world-wide sales for Texaco Inc. **Kerryn King,** formerly vice president in charge of the employee and public relations department, named vice president and assistant to the chairman. **Ben Halsell,** formerly director of advertising and sales promotion is now vice president in charge of the employee and public relations department. Epley succeeds the late Harris T. Dodge.

Tom P. Walker, Houston, former chairman of the board of Transcontinental Gas Pipe Line Corp., was elected to the board of directors of Burgess-Manning Co., Libertyville, Ill., and Dallas, Tex.

Dr. Robert R. White, was elected vice president of the Atlantic Refining Company and general manager of the research and development department. Dr. White has been serving as director of the Institute of Science and Technology at the University of Michigan. He served previously as associate dean of the College of Engineering and the Horace H. Rackham School of Graduate Studies at the University.

Dr. R. R. White

M. W. Crowe

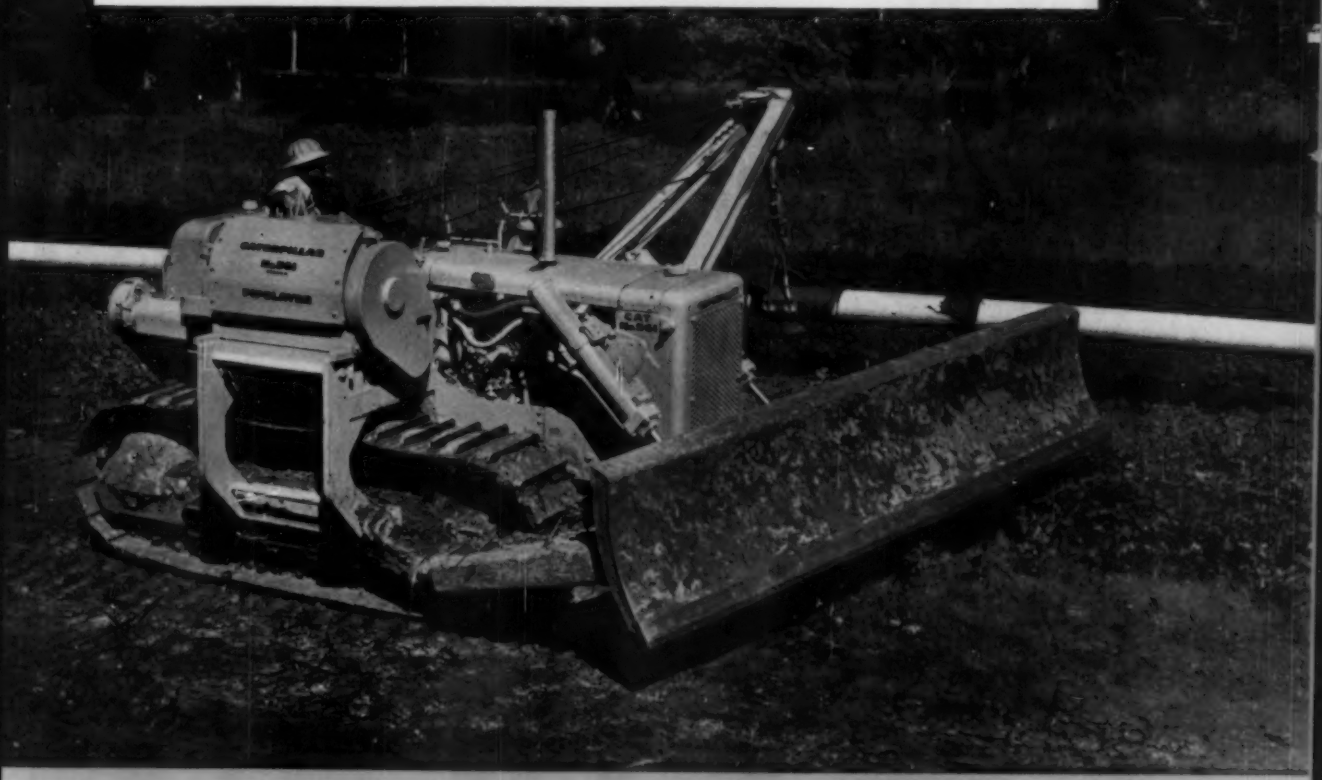
Marvin W. Crowe, Houston, is promoted to director of personnel development and safety for Continental Oil Company. **Carl B. Adams** continues as director of safety and chief fire marshall, reporting to Crowe.

Patrick K. Moore was promoted to director of Conoco's tabulating accounting division, succeeding **Walter H. Scheihing,** retired. **B. H. Taylor,** succeeds Moore as assistant director of the tabulating accounting division.

Thomas B. Kimball, has been elected executive vice president-operations, Sinclair Oil Corporation. **C. J. Allen,** a vice president, was elected president and chief executive officer of Sinclair Refining Company, succeeding Kimball. In his new post, Kimball coordinates the operating activities of all domestic and foreign subsidiaries for the parent company.

World's Biggest
Proven Reserves...
of natural gas CONSUMERS!
Long the Number One metropolitan area of the nation, the New York-Newark area just keeps on getting bigger, assuring a ready market for your production via Transco, the pipeline to the market where the most people are.
TRANSCONTINENTAL
GAS PIPE LINE CORPORATION

Cat 561 Series B shown here without counterweights at work in Texas handling 10" pipe. For lifts up to 38,800 lb., three counterweight arrangements (fixed and hydraulically adjustable) are available. D333 Engine delivers 93 flywheel HP with high torque at low speed. Has Cat Oil Clutch, lifetime lubricated rollers.



MD7 AND 561 PIPELAYERS ...Caterpillar makes 'em

TAKE THE CAT 561 PIPELAYER—G. W. Townsend Lease Service (Bay City, Texas) used a 561 to lay four miles of 10" and 12" natural gas line for Pan American Petroleum Corp. near Sweeny, Texas. In open country, 600' of pipe was lowered into a 48" by 24" ditch in two hours. In close quarters, an average of 2000' of pipe was lowered in daily.

What do the Townsend people think of the 561? They like the way it handles. They like its balance and the way it responds—fast and accurately. The operator singled out the placement of controls. They're in easy reach, without stretching. Their location permitted him to keep his eyes on the work as he moved along the ditch.

With an angle filler up front, Townsend's 561 takes on extra jobs—backfilling and other utility work. (Another contractor put a No. 6A blade on his 561, uses it for right-of-way clearing. The 561's integral hydraulic system—optional—makes it easy to handle a blade, keeps pump and valves under the hood out of the way.)

All in all, the 561 does the kind of job you expect of Cat Pipelayers. *Dependable*—work done quickly and economically.

OR TAKE THE MD7—Ford, Bacon & Davis Construction Corp., Monroe, La., had about 30 miles of 12" pipe to lay south of Welsh, La., for

Cat MD7 is shown cradling pipe in Louisiana marshland. The Series D MD7 has greater power (140 flywheel HP and 54,200 lb. lifting capacity), improved torque rise (boosts lugging ability by 80%), and there's a new dry-type air cleaner, new, stronger final drives, and many other advantages to boost production and lower costs.

to make money for you

the Louisiana Pipeline Company. The route met an average of three irrigation canals per mile, in addition to Louisiana bayous and swamps. Even so, with three new Cat MD7 Pipelayers in the spread, 4000′ to 5000′ were laid every day.

The MD7's seven-roller track frame and 22″ track shoes give the new Cat Pipelayer exceptional stability and flotation needed in swamps and bayous. No wonder, then, that Ford, Bacon & Davis are pleased with the performance of the new MD7s. They bought them for high production under tough conditions. And that's what they're getting.

These new Cat Pipelayers have what it takes to turn in performance records even better than previous models. Extra production slashes operating and maintenance costs . . . see your Caterpillar Dealer for the whole story on the new pipelayers. Ask for an on-the-job demonstration.

Caterpillar Tractor Co., General Offices, Peoria, Illinois, U.S.A.

CATERPILLAR

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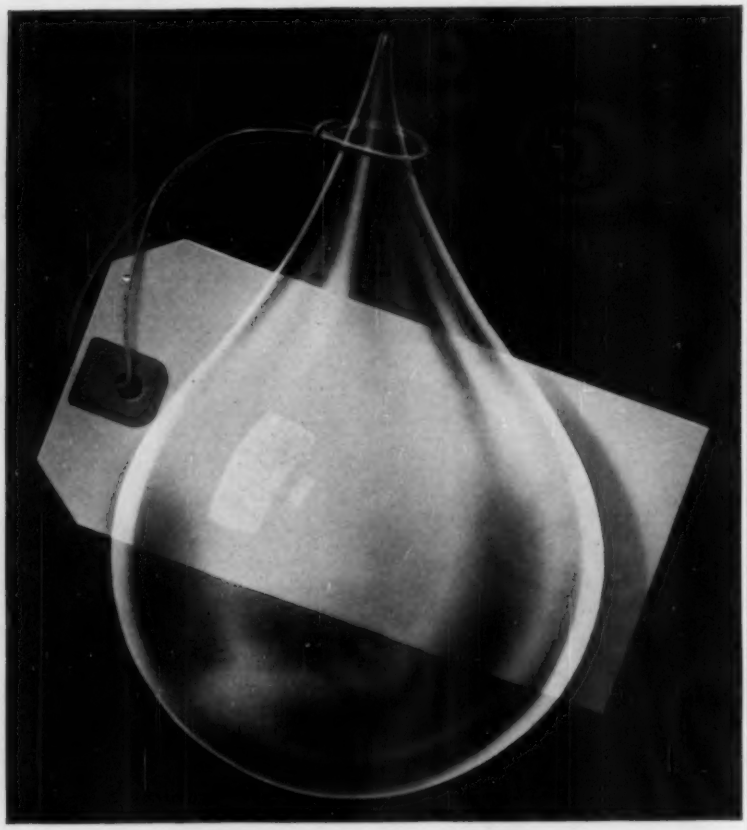
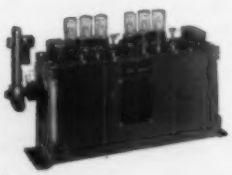
MODERN, HEAVY-DUTY PIPELAYERS FOR THE HARD WORK

What's the PRICE TAG



on a drop of oil?

The drop of oil that isn't there when it's needed can really cost you! That's why you should choose Manzel force-feed lubricators for your lubricating needs. They deliver just the right amount of oil to bearings, cylinders and packing... starting, stopping, speeding up and slowing down in synchronization with your machinery. They're unaffected by high steam, gas or air pressure. Whatever your lubrication needs, Manzel lubricators can save you money. For our catalog, write Manzel, 255 Babcock Street, Buffalo 10, New York. You'll solve all your lubricating problems if you...



ask the man from

A UNIT OF HOUDAILLE INDUSTRIES, INC.

Manzel

SPECIALISTS IN LUBRICATORS AND METERING PUMPS SINCE 1898

▸ **Max S. Simpson,** was elected comptroller of Socony Mobil Oil Company Inc. He succeeds **Phillips C. Salman,** retired.

▸ **Frank O. Prior,** (right) chairman of the board and chief executive officer of Standard Oil Company (Indiana), retired after 41 years' service. President **John E. Swearingen** (left) became chief executive officer.

▸ **Frank Gaines Jr.** joined headquarters of Humble Oil and Refining Company as coordinator of executive development and organization planning. Gaines was serving as production manager of the Carter Division's eastern area. **Robb Oertel** retired from Esso Standard Division where he has been manager of aviation sales since 1935.

▸ **Herbert C. Thober** was appointed manager of Sun Oil Company's Toledo, Ohio refinery. Thober replaces **John F. Harron,** who moved to Sun's advanced management and methods division.

▸ **C. Wesley Michaels** was appointed manager, planning and market research for industrial electronic products, Radio Corporation of America. He reports to **J. J. Graham,** division vice president and general manager, RCA communications and controls division.

▸ **Dr. Horace N. Lander** is named assistant director of research for The Youngstown Sheet and Tube Company. He formerly served as research supervisor for Jones & Laughlin Steel.

▸ **T. R. Harrison** was named assistant treasurer of Dowell Division of The Dow Chemical Company. He succeeds **E. W. Smith,** who has been transferred to Europe as foreign accounting representative for Dow Chemical International Limited S. A.

Deaths

▸ **Fabian R. Staley,** 64, retired chemical engineer, died August 5 at Tulsa, Oklahoma. Mr. Staley was the first editor of *The Petroleum Engineer.*

▸ **Michael Halpern,** 67, former senior vice president and director of Texaco Inc., died August 16 at Shawnee-on-Delaware, Pa.

▸ **DuBois Eastman,** 54, director of the Montebello Research Laboratory of Texaco Inc., died August 12.

FOR **fun** IN **CALIFORNIA**

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★ Rooms, kitchenette units, suites
★ Room phones
★ Free TV
★ Air-conditioning
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If you're healthy, you'll probably live longer because as it's said, "an ounce of prevention is worth a pound of cure." If you're nervous, tired, rundown or stiff from rheumatism and arthritis, you can find relief as thousands of others have. *You'll find the best at The Majestic* where you can go from your room to the bathhouse in robe and slippers. Here you will find specialists who know their business—experienced attendants and masseurs for the men and masseuses for the ladies—all licensed in accordance with the regulations under the Director of the Nat'l Park Service, U. S. Dep't of the Interior.

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HEATED SWIMMING POOL
Write the MAJESTIC today!

ROOMS *from—* $4.50 *per day single* $8—*double and you can budget* MEALS *at* $4.50 *per day*

THE
Hotel in the Oil Capital of the World

100% Airconditioned
600 Bright *Reasonably* Priced Rooms

THE MAYO

TULSA'S *Finest* HOTEL
Sample Rooms – Finest Food
Adjacent Garage

relief *from* **tension**

Let the radioactive waters of world-famous Hot Springs National Park banish all your aches and pains due to tension and occupational fatigue—ease arthritis, rheumatism and high blood pressure. Countless thousands have benefited from these wonderful thermal baths— Superb bathhouse right in hotel.

All sports available, including golf with club privileges, game fishing, and water sports. Entertainment and social diversions.

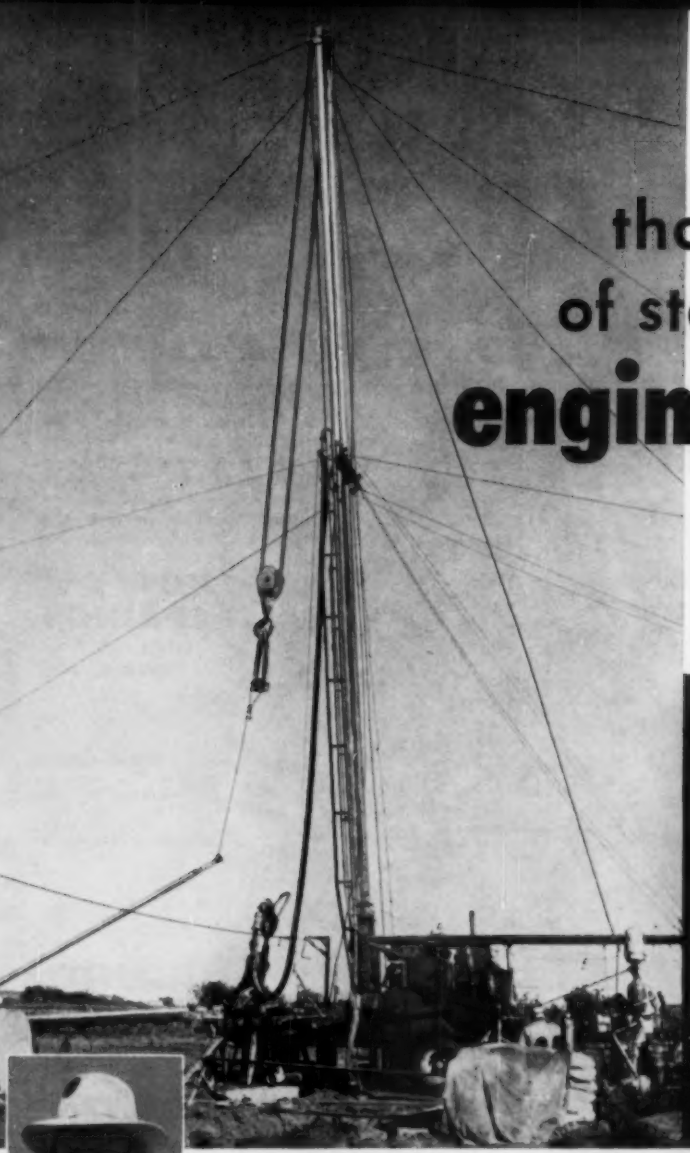
THE *Arlington* HOTEL and BATHS
HOT SPRINGS
NATIONAL PARK ARKANSAS

Write for Your Free Color Folder

OUR OWN TWIN CASCADE SWIMMING POOLS
You will enjoy the new twin cascade temperature-controlled swimming pools, patio and sun decks accessible from the Arlington.

R. E. McEACHIN
General Manager

After more than 15,000 hours of steady operation engine still runs like new!



UV-549 V-8 engine 257 max. hp @ 3,400 rpm gasoline, LP gas or natural gas.

Report from drilling superintendent, W. F. Hicks

"Since December, 1957 this International V-8 has run almost continuously, 24 hours a day, supplying the smoothest, most efficient power a driller ever had. When we had a chance to take the head and pan off after more than 11,000 hours operation, we couldn't find any wear that could be measured, felt, or seen. Since then we have drilled another 75,000 feet of hole, and added 4,454 hours of operating time on this engine. And it still runs like new!"

A three-man crew handles this specially built rig for Davis & Davis, Inc., Coleman, Texas. The pipe is racked horizontally on a platform instead of in a vertical stack, and this eliminates the tower man from the four-man crew normally used on this size operation. It takes them about five days, working three shifts around the clock, to put down an average well of 2,300 feet. The International UV-549 powers draw works, rotary table and cat head.

International oil field engines are adaptable to meet your needs. Choose fuel attachments for natural gas, combination natural gas and gasoline, LPG, or dual fuel—LPG and natural gas. Water cooled exhaust manifold, top cylinder oiler, automatic safety shut-off, oil sight level gage, low-tension magneto, and gear-driven mechanical governor are available. Check with your International Power Unit Distributor or Dealer for drill, pump and compressor power. Choose from 24 engines—16.8 to 385 max. hp.

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Meetings . . .

Oct. 6-7 — **National Assn. of Corrosion Engineers**, annual Western region conference, Sheraton-Place Hotel, San Francisco, Calif.

Oct. 6-8 — **National Assn. of Corrosion Engineers**, Southeast region conference, Dinkler-Plaza Hotel, Atlanta, Ga.

Oct. 9-13 — **ASTM**, Committee D-2 meeting, Mayflower Hotel, Washington, D. C.

Oct. 10-12 — **American Gas Assn.**, annual convention, Atlantic City, N. J.

Oct. 11-14 — **National Assn. of Corrosion Engineers**, Northeast region conference, Prichard Hotel, Huntington, W. Va.

Oct. 12-14 — **Southwest Federation of Geological Societies**, annual meeting, Abilene, Tex.

Oct. 12-14 — **American Vacuum Society**, seventh National Symposium, Cleveland — Sheraton Hotel, Cleveland Ohio.

Oct. 13-14 — **California Natural Gasoline Assn.**, annual fall meeting, Hotel Miramar, Santa Monica, Calif.

Oct. 17-19 — **Production Drilling & Blasting Symposium**, 10th annual, Colorado School of Mines, Golden, Colorado.

Oct. 19-20 — **National Assn. of Corrosion Engineers**, North Central region conference, Schroeder Hotel, Milwaukee, Wis.

Oct. 19-21 — **Rocky Mountain Oil and Gas Assn.**, annual convention, Brown Palace Hotel, Denver, Colo.

Oct. 20 — **National Industrial Conference Board**, meeting of board members, Hotel Pierre, New York City.

Oct. 20-21 — **Society of Petroleum Engineers of AIME**, Los Angeles Basin section, Huntington-Sheraton Hotel, Pasadena, Calif.

Oct. 23-25 — **Independent Petroleum Assn. of America**, annual meeting, Statler-Hilton Hotel, Dallas, Tex.

Oct. 23-25 — **Pennsylvania's Petroleum Assn.**, Management Institute, Penn State University, University Park, Pa..

Oct. 23-26 — **North American Gasoline Tax Conference**, LaSalle Hotel, Chicago, Ill.

Oct. 25-27 — **American Standards Assn.**, 11th National Conference on Standards, Sheraton-McAlpin Hotel, New York City.

Oct. 25-28 — **National Assn. of Corrosion Engineers**, South Central region conference, Mayo Hotel, Tulsa, Okla.

Oct. 26-27 — **WPRA**, Refining Technology, Rufus Garrett Hotel, El Dorado, Ark.

Oct. 28 — **Natural Gasoline Assn. of America**, Southern regional meeting, Carlton Hotel, Tyler, Texas

Oct. 31-Nov. 1 — **National Lubricating Grease Institute**, annual meeting, Edgewater Beach Hotel, Chicago, Ill.

Oct. 31-Nov. 2 — **National lubricating Grease Institute**, 28th annual meeting, Edgewater Beach Hotel, Chicago, Ill.

Nov. 3-4 — **Society of Automotive Engineers**, national fuels and lubricants, Mayo Hotel, Tulsa, Okla.

Nov. 3-4 — **AAPG**, Pacific Section, annual meeting, Ambassador Hotel, Los Angeles, Calif.

Nov. 7-10 — **SEG**, 30th annual international meeting, Moody Convention Center, Galveston, Tex.

Nov. 14-16 — **Society of Petroleum Engineers of AIME**, Venezuelan sections, 4th annual meeting, Site unreported, Maracaibo, Venezuela.

Nov. 14-16 — **American Petroleum Institute**, annual meeting, Conrad Hilton, Palmer House and Congress hotels, Chicago, Ill.

Nov. 15-16 — **Natural Gas Pipe Line Institute**, Court House, Liberal, Kans.

Nov. 15-16 — **API**, Board of Directors meeting, Conrad Hilton Hotel, Chicago, Ill.

Nov. 16 — **API**, Executive Committee of Board of Directors, Conrad Hilton Hotel, Chicago, Ill.

Nov. 17 — **National Industrial Conference Board**, general session, Penn Sheraton Hotel, Pittsburgh, Pa.

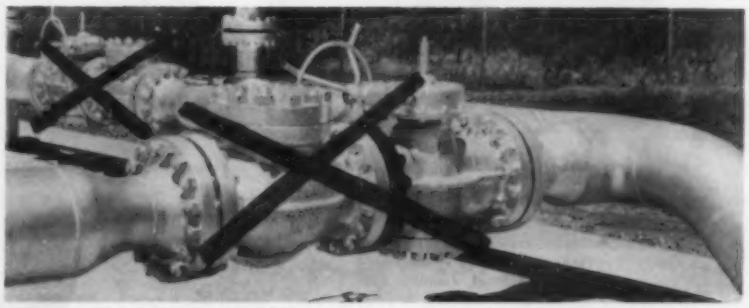
Nov. 18 — **Natural Gasoline Assn. of America**, Panhandle Plains regional meeting, Herring Hotel, Amarillo, Tex.

Nov. 21-22 — **Society of Petroleum Engineers of AIME**, formulation evaluation conference, Cullen Auditorium, University of Houston, Houston, Tex.

Nov. 27-Dec. 2 — **American Society of Mechanical Engineers**, annual winter meeting, Statler Hilton Hotel, New York, N. Y.

WHY BUY 2 ? . . . WHEN 1 WILL DO!

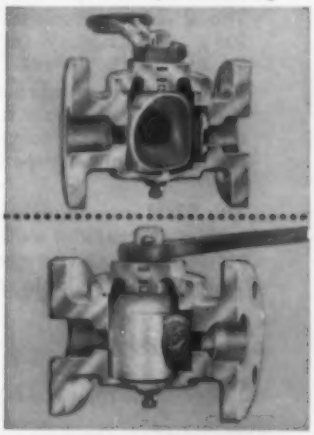
ONE FRANK WHEATLEY PLUGAROO!



Get TWO-IN-ONE for the Price of ONE!

- The Plugaroo is a combination non-lubricated plug and check valve!
- The Plugaroo completely eliminates the need of one valve!
- Save 50% by buying the PLUGAROO!
- Over 20,000 now in use!
- Available in sizes 2" to 10"; full or regular opening!
- Example: Factory shipment price for 2" screwed ends — only $10.39.
- Send for descriptive literature or see pages 5634 and 5635 in Composite Catalog.

Why buy two valves, when one non-lubricated PLUGAROO combination plug and check valve . . . will do the job better and cheaper? As a check, the clapper-hinged on a 20° angle . . . seals under its own weight. As a plug, a quarter turn gives a positive seal without galling or scoring plug, clapper, or valve body. Available with Teflon or Synthetic Rubber seals in steel, semi-steel, or aluminum bronze from Series 15 to 90. Full opening sizes 2" to 10" in all API, ASA dimensions and end connections. Write for further details.



Cut-away illustrates **PLUGAROO** with plug "closed" (top) and as check valve "open" (bottom).

SINCE 1916

FRANK WHEATLEY

PUMPS & VALVES TULSA, OKLAHOMA

ALSO NEW . . .

the **SLAM-MINIMIZER CHECK VALVE** for high pressure gas lines . . . and the new **SPHERE-CLEAR CHECK VALVE** for lines using ball-markers for interface and batch change.

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YOUR SUPPLY STORE SHOULD HAVE THEM!

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Galvanized Weatherproof, Tamperproof Control Box

Patents Pending

- **PVM for positive measurement of liquid from separator, treater or tank**
- **PVM for positive determination of well production for proration or commingling**
- **PVM and core barrel sampler for positive determination of B S & W content**

The PVM overcomes the difficulty in obtaining 100% repeatability inherent in other types of cyclic volume meters.

The PVM is fluid packed, sampled and then counted as the liquid is discharged. Its accuracy is indisputable as to volume of liquid measured at the pressure-temperature condition of operation.

The PVM may be calibrated for an exact volume with compensation made for a given composition, temperature and pressure.

The PVM is available with Core Barrel Sampler* which will complete the requirements for metering oil field liquids. The Sampler cuts a core vertically through the liquid and deposits same in a container. Thus an exact and representative core is taken from a fixed volume. The composite sample when analyzed will give the true percentage of oil, water and/or emulsion that has been metered.

NATIONAL'S PLUS VALUE — Engineers and field service crews available from over 50 service and warehouse stocking points to size, install and service National PVMs.

* Core Barrel Sampler is a trademark of National Tank Company

It's a National®

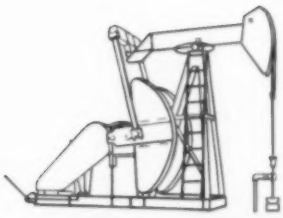
NATIONAL TANK COMPANY

DRAWER 1710

TULSA, OKLAHOMA

SERVICE LIKE *NOW!*

When you buy a Cabot Pumping Unit you buy more than the unit itself. You're buying *fast, courteous service* for that unit day or night . . . 365 days a year! Cabot maintains convenient service centers throughout the oil country, each having a complete stock of Cabot Pumping Unit parts and staff of factory trained personnel. If you are not now using Cabot units . . . make your next one a Cabot! You'll prove to yourself that *Cabot Quality* plus *Cabot Service* adds up to the tops in dependable pumping.

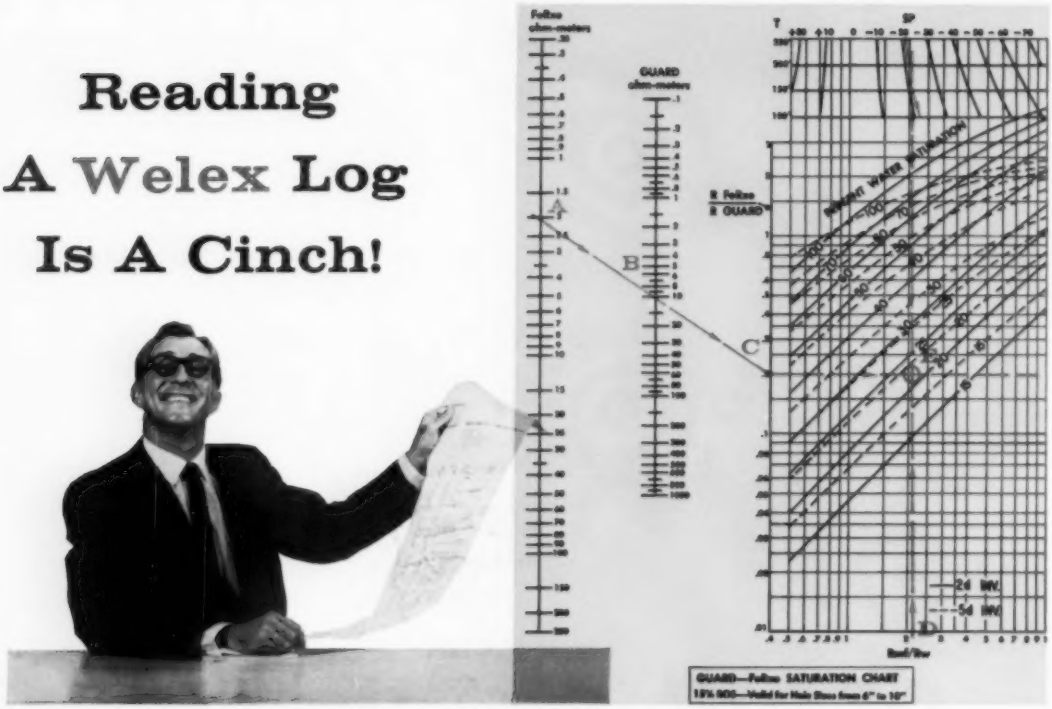


CALL YOUR J&L MAN...

OIL FIELD PUMPING EQUIPMENT
CABOT
PAMPA, TEXAS
FRANKS

CABOT CORPORATION
MACHINERY DIVISION

Reading A Welex Log Is A Cinch!



That's right — it's as easy as drawing a straight line.

With Welex's new simplified interpretation charts, or "pigtails," printed right on the log where they are always convenient, you can read POROSITY directly off the log and calculate FLUID SATURATION in seconds. No complicated computations are needed.

To use the Guard-FoRxo "pigtail" above to figure FLUID SATURATION, follow these simple steps. In this example, values read directly off the log in the zone of interest were: FoRxo 2 Ohms; Guard 10 Ohms; SP (self potential) —22 millivolts.

A. Pinpoint the FoRxo value on the FoRxo scale.

B. Pinpoint the Guard value on the Guard scale.

C. Connect points "A" and "B" with a straight line and extend it to intersect the side of the water saturation chart at point "C". Draw a horizontal line from point "C" across the chart.

D. Pinpoint the Rmf/Rw value (if known from Rw data in the area) on the Rmf/Rw scale at the bottom of the chart and raise a vertical line to intersect the horizontal line at point "E". (If Rw data is not available, an alternate method is to pinpoint the SP value (—22 millivolts) on the SP scale at the top and drop a vertical line.)

E. Read the percent of FLUID SATURATION at the intersection of the two lines.

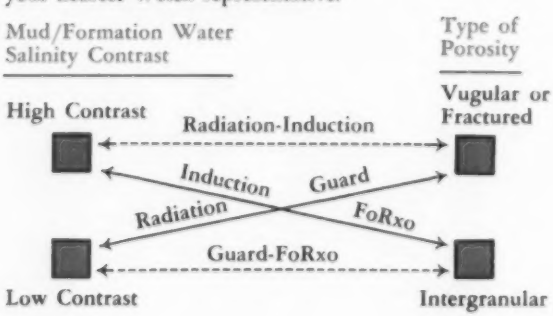
The answer in this illustration is 22 percent.

And just as simple as the "pigtail" is the actual selection of the right logging service for your well, thanks to Welex's new simplified logging program. Based on type of porosity and the salinity contrast between drilling mud and formation water, the diagram here shows how simple it is to choose the right logs without running any excess logs.

For example, the diagram shows that if the salinity contrast is low and the porosity is intergranular, the best log for your well is Welex's Guard-FoRxo. If the porosity is the same type and the salinity contrast is high, the best choice is the Induction FoRxo.

Fast, accurate and simple — that's Welex's new logging program. The Guard-FoRxo, the Induction-FoRxo, Radiation-Guard and Radiation-Induction, each with its own easy-to-use "pigtail," give fast, accurate answers in more than 90 percent of today's wells.

For the right logging answer for your well, call your nearest Welex representative.



WELEX, INC.

ORIGINATORS OF JET PERFORATING

General Offices: 1400 East Berry, Fort Worth, Texas
In Canada: Welex of Canada, Ltd.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Of Things To Come . . . In Oil

LOWER DRILLING COSTS ARE CERTAIN RESULTS of such extensive industry research as is being performed at Jersey Production Research Company facilities in Tulsa. Look for: hydraulic wall-anchored drill collar to replace conventional collars; downhole recorder to study forces and motions at the bit; bit design improvements from Jersey's high pressure chamber for studying rock failure under formation conditions; fluid-entry analyzer and downhole flowmeter to measure location, direction, amount, and type of fluid entering a well bore.

ALUMINUM PELLETS AS PROPPING AGENTS have been developed for high fracture conductivities by Atlantic Refining Company and Reynolds Metals Company. Properties of the metal pellets make them especially suitable for use in fracturing highly permeable formations in which propping sand is often crushed or sinks into the formation. Extremely successful field tests portend greater use of the new fracturing process.

LOUISIANA'S NEW SPACING REGULATIONS are designed to encourage wildcat drilling and at the same time curtail production. New rules will grant a production bonus for wells drilled on spacing larger than conventional 40-acre units. Only new pools would be subject to proposed rulings which provide for production bonus in proportion to spacing over 40 acres but less than 80 acres. Louisiana Conservation Department hopes new order will permit oil companies and other operators to hold leases without drilling as many wells as in the past.

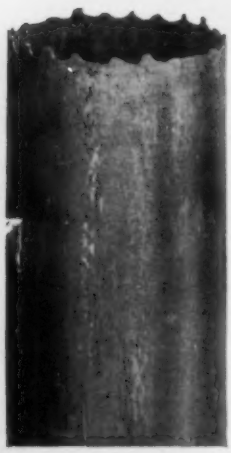
RUSSIA WILL FULFILL SEVEN-YEAR PLAN to double its 1958 oil production by 1965. Such is the consensus of three oil company executives who recently completed a month's tour of Russian oil fields and refineries. Ira H. Cram, Continental Oil Company, W. W. Keeler, Phillips Petroleum Company, and George T. Piercy, Standard Oil Company of New Jersey, agreed that although the U. S. has a technological lead over the U.S.S.R., Russia can still produce "a whale of a lot of oil."

SPRABERRY WATERFLOODS WILL INCREASE ultimate recovery by 186 million bbl from three large projects recently approved by the Texas Railroad Commission for Sohio Petroleum Corp. (61,256 acres), Humble Oil & Refining Company (23,568 acres), and Southland Royalty Company (15,776 acres). At least ten other such projects are pending before the Railroad Commission.

Lower a McCullough Chemical Tubing Cutter to the desired depth. Push a button. Before you can snap your fingers, your tubing is cut.

This electric wire line tool applies the enormous power of halogen fluorides to cut tubing as easily as a knife cuts through hot butter — and it's a smooth, flare-free cut — no burrs nor distortions on either the OD or ID of the tubing.

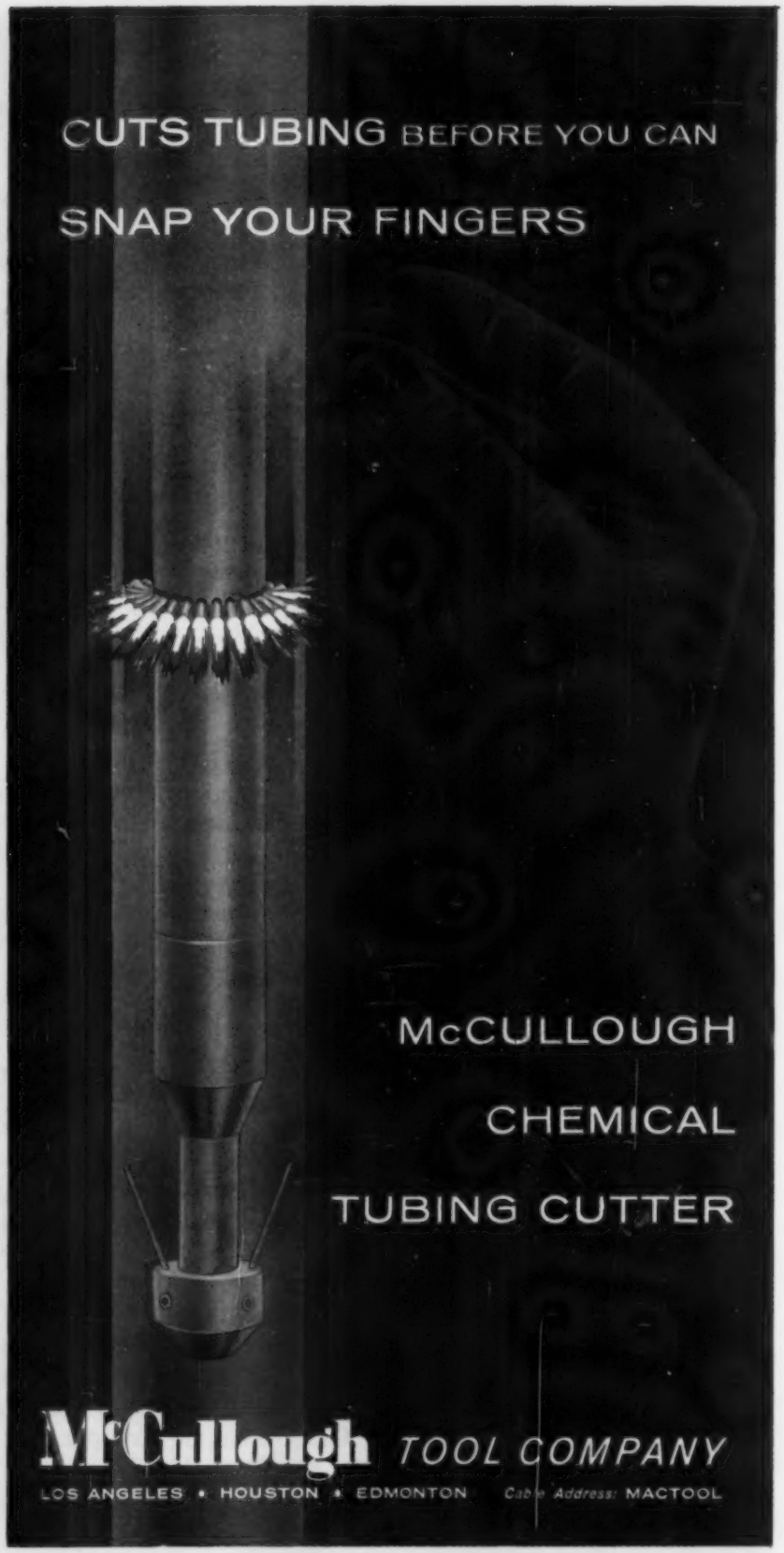
Cutting action is closely controlled. The outside casing



or tubing will not be damaged. Entire operation is 100% junk-free, as no part of the cutter is expendable.

Compared to mechanical methods, you will make significant savings in valuable rigtime when you use the McCullough Chemical Tubing Cutter. Available for 2" and 2½" tubing at all McCullough Service locations.

Additional Service Representative: Houston Oil Field Material Company, Inc.



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Martin-Decker Electric Drillogc Recording Systems

For the recording of Total Hook Load, Pump Pressure, Pump Speed, Rotary Speed, Torque, Rate of Penetration, and R. P. M. Signals, and Pressure Signals to 20,000 pounds . . . Write for Bulletin No. P90.

MARTIN DECKER

Write for descriptive literature

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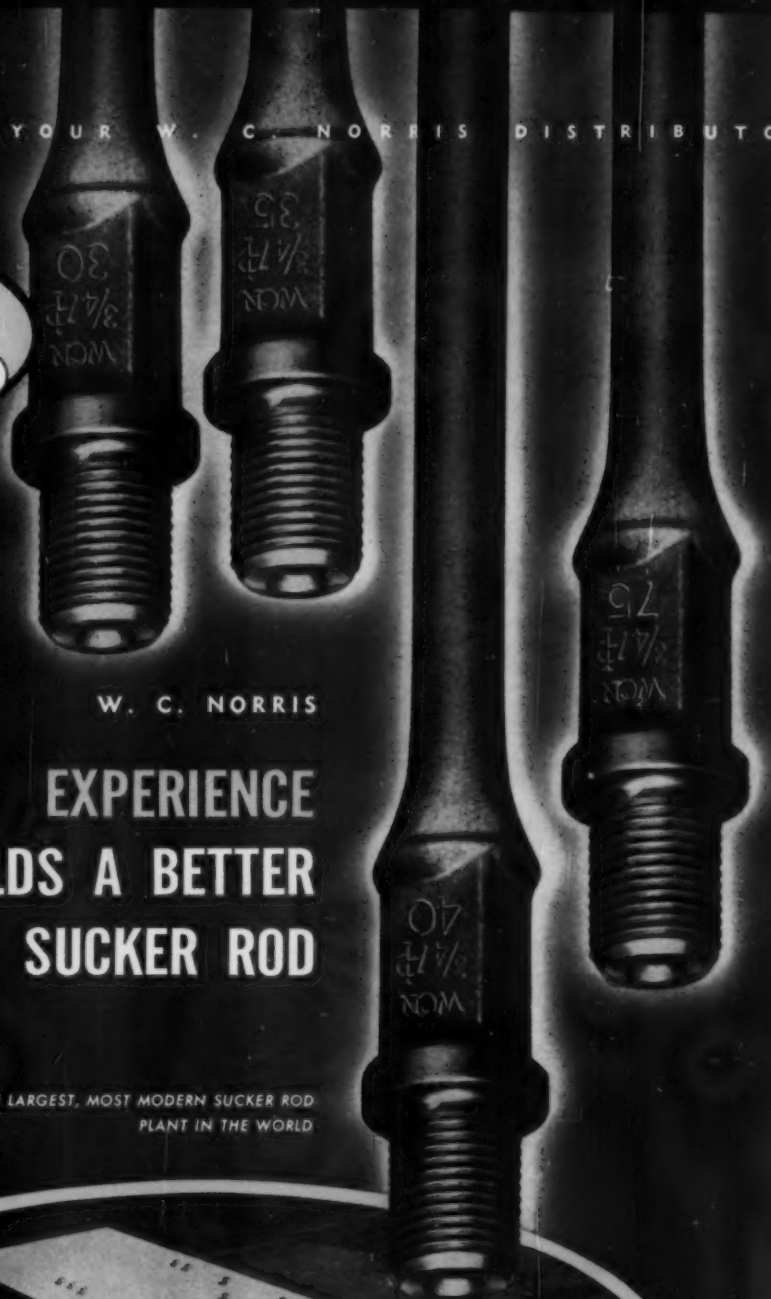
The World's principal manufacturer of Oil Well Drilling Instrumentation

BUY FROM YOUR W. C. NORRIS DISTRIBUTOR

NORRIS QUALITY
SUCKER RODS
POLISHED RODS - COUPLINGS



W. C. NORRIS

EXPERIENCE BUILDS A BETTER SUCKER ROD

THE LARGEST, MOST MODERN SUCKER ROD PLANT IN THE WORLD

W. C. NORRIS, MANUFACTURER
DIVISION OF DOVER CORPORATION
TULSA, OKLAHOMA • P. O. BOX 1739

BRANCHES: Great Bend, Kansas; Corpus Christi, Houston, Kilgore, Odessa, Wichita Falls, Texas; Oklahoma City, Oklahoma; Salem, Illinois; Casper, Wyoming; Farmington, New Mexico; Edmonton, Alberta, Canada,

BULL PLUGS

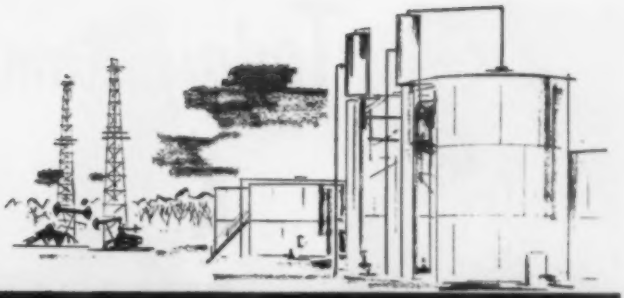
SWAGED NIPPLES

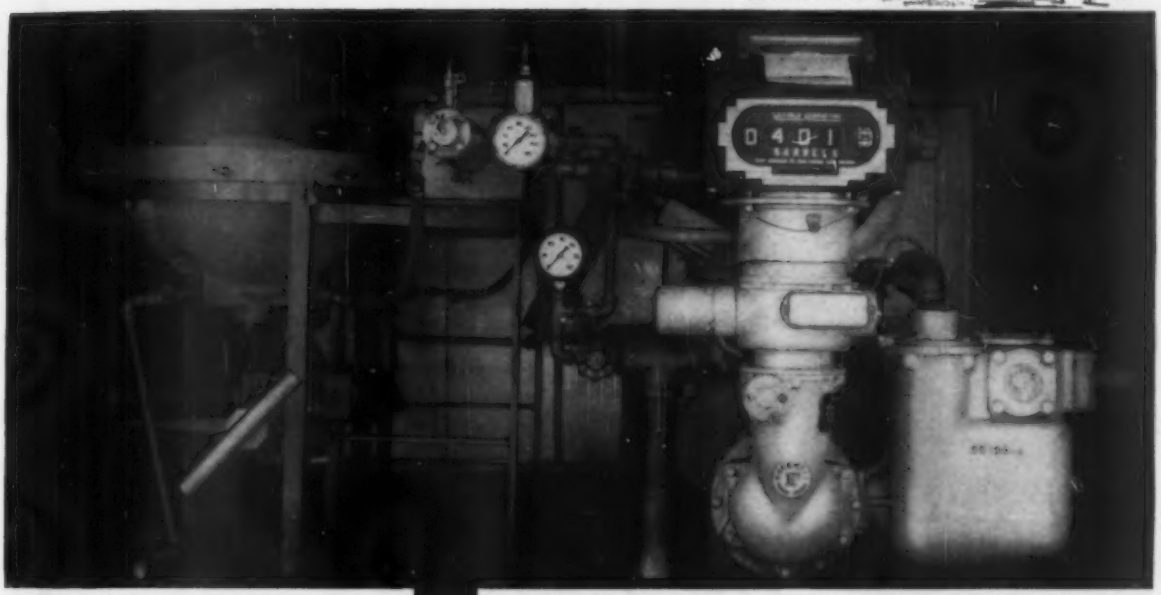
• OTHER NORRIS CHAMPIONS

VALVES 150 PSI

WELL HEAD EQUIPMENT

Out on the lease...





Two Rockwell Rotocycle T-70 meters mounted back to back in a cabinet on lease in Wyoming. Meters are fitted with air eliminators, temperature compensators, impulse contactors and ticket printers.

You'll benefit from the accuracy and convenience of Rockwell Rotocycle meters

This model 2 BH Rockwell Rotocycle meter measures oil from tank battery into a pipeline at Big Muddy field near Casper, Wyoming.

On ACT and LACT services, Rockwell Rotocycle meter systems will save you time, trouble and money. Rotocycle meters have an all-revolving measuring mechanism. They turn freely on anti-friction bearings without metal-to-metal contact. Rockwell air eliminators remove all entrapped vapors. Automatic temperature compensators assure measurement at a uniform base temperature. Ticket printing registers verify quantities, simplify accounting. Electric impulse contactors actuate remote counters and/or control accessories such as solenoid valves for automatic shut-off.

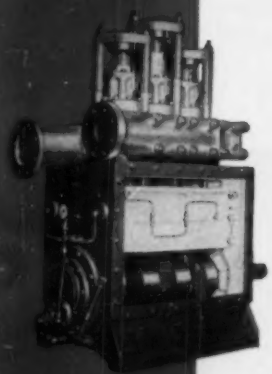
The advantages in the Rockwell system include (1) the highest degree of accuracy and conservation control (2) lower operating costs and (3) reliable records upon which to base transfer and tax payments. For details write Rockwell Manufacturing Co., Dept. 123K, Pittsburg 8, Pa. In Canada: Rockwell Manufacturing Co. of Canada, Ltd., Box 420, Guelph, Ont.

OIL FIELD METER SYSTEMS

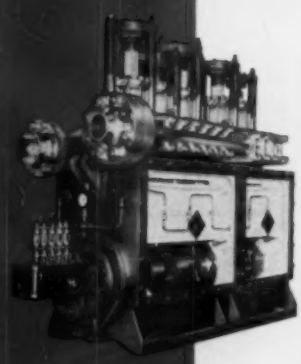
another fine product by

ROCKWELL

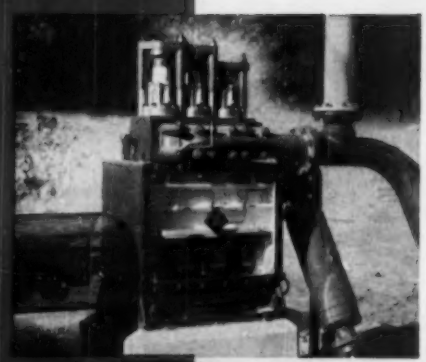
Today...tomorrow and Always-



Triplex Pump



Quintuplex Pump



Type [illegible] Pump

A FULL DOLLAR'S VALUE FROM AJAX *Equipment*

ECONOMICS TODAY

BY AJAX

Even in these days there are still some ways and places to obtain as much value for your dollar as you ever did.

One of these ways is to purchase known and proven quality products.

Such as Ajax products...

Purchasing low priced and less than the best quality in products at today's inflated values means you lose even more when it must be replaced sooner at inflated values.

Today's high taxes and diminishing returns demand careful equipment investment more than ever before.

You can trust Ajax VALUE . . . you can trust AJAX EQUIPMENT — today, tomorrow—and always.

AJAX

AJAX OIL FIELD PUMPS

AJAX . . . also builders of COMPRESSORS — ENGINES

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Oil Field Distributors

- The National Supply Co. — Pittsburgh, Pennsylvania
- Bethlehem Steel Co. — Supply Division, Tulsa, Oklahoma
- Mid-Continent Supply Co. — Fort Worth, Texas

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Down Hole Reaming

You can get from Grant!

This is just one of the three *families* of Grant Tools made for reaming, hole enlarging and stabilizing. For full information on these, and a wide range of other down-hole and surface tools made by Grant, send for your copy of the complete Grant Catalog today, or see the Grant section of Composite Catalog!

When you order out your next Reamer—*call Grant*. Different well conditions, different formation, depth and drilling requirements, and even different preferences have resulted in *three* distinct Grant Reamer types to meet *every* need. Then add

Six cutter types for every formation
Three, six or *nine* point body styles
Size ranges for *all* hole diameters

and you have an unlimited selection of Grant Reamers for reaming any well you drill . . . stocked and serviced by Grant in active areas *everywhere*.

It pays to ream *right*. And to use the *right* reamer, call Grant—*because only Grant makes them all!*

GRANT OIL TOOL COMPANY

2042 EAST VERNON AVENUE, LOS ANGELES 58, CALIFORNIA
Cable Address: GRANTOOL

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You save drilling dollars with

THE

MUD PROBLEM: Overcome pressure differential sticking (wall sticking) of drill pipe and casing.

WELL DATA

Location: Lake Boeuf Field, Lafourche Parish, Louisiana
Total Depth: 13,685′

MUD ADDITIVE PROGRAM

0′ to 8,000′	Native mud plus AQUAGEL*, caustic soda and Q-BROXIN**
8000′ to 13,685′	Gyp—Q-BROXIN emulsion. TRIMULSO* and DMS† below 7″ liner depth

TYPICAL MUD PROPERTIES

Depth	12,000	12,800	13,315[1]	13,653[2]
Weight, ppg	15.8	16.1	16.1	18.1
Viscosity, sec. API	60	55	60	65
Plastic Viscosity, cp	50	48	52	71
Yield Point lb/100 sq ft	15	7	12	14
Filtrate, cc API	21.8	2.0	2.2	0.5
Calcium, ppm	840	1360	1600	720

[1]Before addition of TRIMULSO and DMS
[2]After addition of TRIMULSO and DMS

CASING PROGRAM

Size Inches O.D.	*Depth Set Feet*
13⅜	3,022
9⅝	10,997
7 (liner)	13,301
5 (liner)	13,685

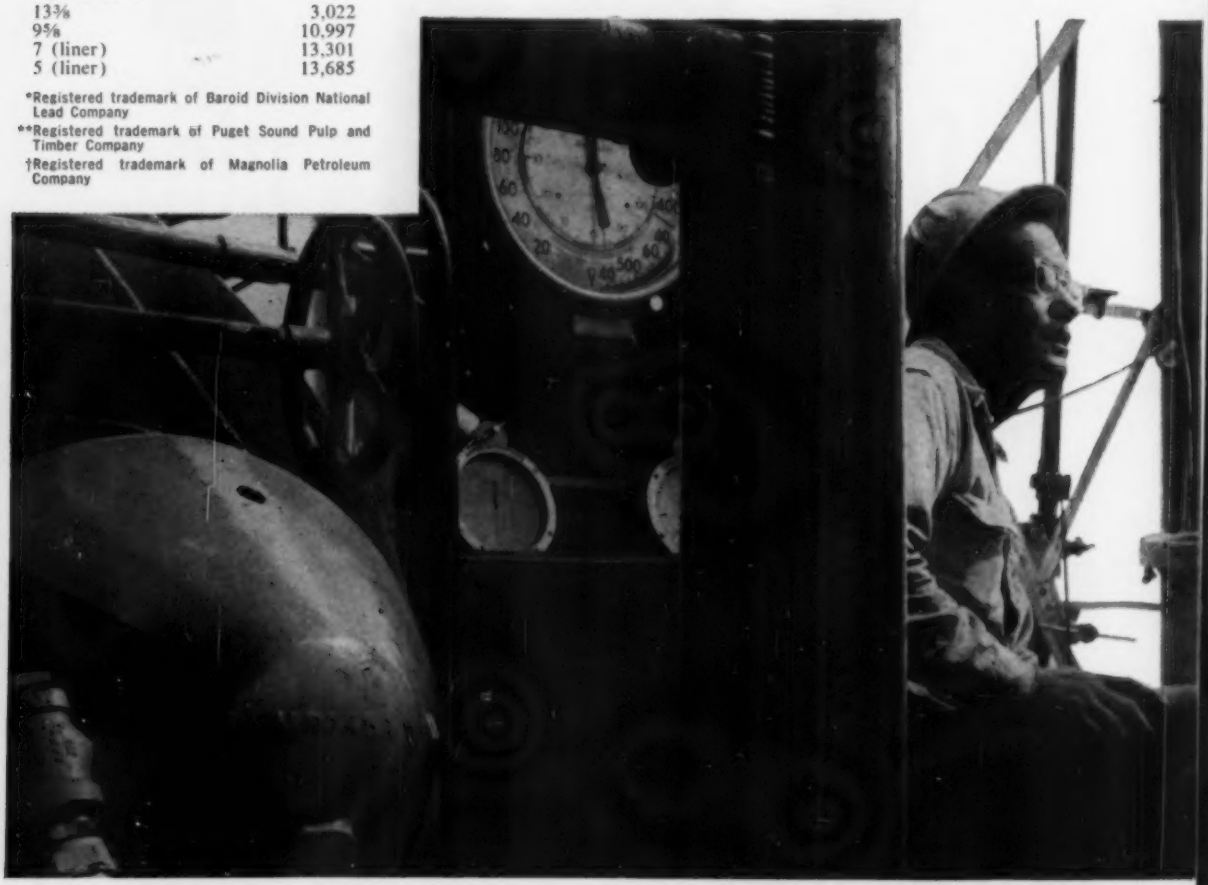
*Registered trademark of Baroid Division National Lead Company
**Registered trademark of Puget Sound Pulp and Timber Company
†Registered trademark of Magnolia Petroleum Company

PROBLEM: To prevent differential sticking of drill pipe. Insure landing and cementing of liner at total depth.

DISCUSSION: High mud weights are required to contain abnormally high formation pressures in this field. The difference between the mud column pressure and the pressure in the porous zones may cause differential sticking of drill pipe and liners. Differential sticking is evidenced by: the tendency for drill pipe to stick while making connections, running directional surveys, etc.; full circulation of the mud is possible while the pipe is stuck; and there may be no previous history of tight hole.

SOLUTION: Pilot tests on mud samples and previous experience with comparable jobs indicated that TRIMULSO would alleviate this troublesome condition. TRIMULSO was added to this emulsion mud while the mud weight was being increased to 18 ppg.

This well was successfully drilled to its objective without any difficulty with stuck drill pipe, and the 5″ liner was easily run and cemented.



a Baroid Mud Program

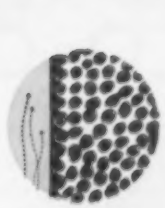
MUD PROBLEM

... and its solution

This case history shows again how a complete Baroid mud program helps accomplish your drilling objective. A costly fishing operation was prevented by the use of the specific product TRIMULSO.

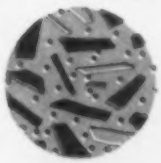
Baroid's previous experience enabled the diagnosis of the potentially costly fishing job that would result from differential sticking. Previous experience also resulted in prevention of the trouble by the engineered use of TRIMULSO.

This is more proof that Baroid's new concept of modern marketing brings you added advantages. You get an *integrated service* that combines engineering skills developed in all drilling areas, quality-controlled products and complete delivery service that *saves your drilling dollars!*



THIN FILTER CAKE

PREVENTS DIFFERENTIAL STICKING



MAINTAINS GOOD EMULSIONS

BAROID

BAROID DIVISION NATIONAL LEAD COMPANY

MAIN OFFICE: P. O. BOX 1675, HOUSTON 1, TEXAS

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WECO NO-GALL TOOL JOINT COMPOUND has more than 50% pure metallic zinc dispersed in a neutral oil with a tacky additive.

WECO LO-TORK TOOL JOINT COMPOUND has 50% metallic lead suspended in a neutral base with a tacky additive.

Treat Your Tool Joints to a WECO COMPOND

WECO Tool Joint Compounds, LO-TORK or NO-GALL, are the treatment your tool joints need for longer life, trouble-free service, easier make-up and breakout.

These Compounds meet every requirement for proper and efficient drill string thread lubrication. They provide low-friction make-up; will not squeeze out under high temperature or torque pressure; will not freeze the joint. They always remain soft in the can under all extremes of hot or cold weather for easy, time-saving application. They never require thinning.

WECO Compounds are stocked by Supply Stores everywhere for your convenience.

WECO

WELL EQUIPMENT MFG. CORP.
HOUSTON, TEXAS
Division of CHIKSAN COMPANY *a subsidiary of* FOOD MACHINERY AND CHEMICAL CORPORATION

C-1-60

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WECO UNIONS

CHIKSAN SWIVEL JOINTS

HAMER LINE BLIND VALVES

HAMER PLUG VALVES

WECO AIR-O-UNION

WECO COMPOUNDS

WECO SNATCH BLOCKS

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Trinity
LITE-WATE

A Complete Low Density Cement with

EXCEPTIONAL COMPRESSIVE STRENGTH

Strength is recognized as one of the important qualities of an oil well cement slurry. TRINITY LITE-WATE cement develops exceptional compressive strengths.

In the range of lightweight cement slurries, TRINITY LITE-WATE produces a slurry which is:

1. Light enough to circulate.
2. Strong enough for any casing seat.
3. Strong enough to permit hydraulic fracturing.
4. Impervious to migrating fluids.
5. Sulfate resistant for lasting casing protection.

For TRINITY LITE-WATE cement call your service company.

For complete Laboratory Data call your local Trinity Representative or write Dallas Office, P. O. Box 2698 or phone RIverside 2-8111.

376 lb. Barrel 94 lb. Sack

75 lb. Dry Volume per cubic foot

SALT
12¼ LB. SLURRY LITE ENOUGH TO CIRCULATE ANY STRING
13½ LB. SLURRY STRONG ENOUGH FOR ANY CASING SEAT
TRINITY HIGH EARLY STRENGTH

TRINITY

PORTLAND CEMENT DIVISION
GENERAL PORTLAND CEMENT COMPANY

DALLAS·FT.WORTH·HOUSTON

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NOW... a superior charge for Maximum Well Flow

The ATLAS-JET – exclusive with PGAC

Here are the FACTS . . . COMPARE for yourself!

PGAC's new 4" ATLAS-JET charges were recently test-fired in a standard flow lab under simulated subsurface conditions of 1500 p.s.i. at 180°F., into targets with ⅜" steel face-plates, ¾" Hydromite, and 15" deep Berea Sandstone (not cement!) confined in 4½" drill pipe, at stand-offs of 0" – ½" – 1" and 2" in fluid. Well Flow Index for all tests: 1.5 min. to 1.7 max.

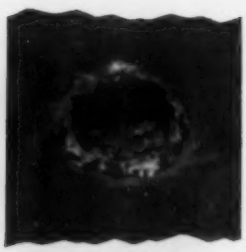
The unretouched photos below show a representative test with ½" s.o., the results of which far surpass the published data for all competitive guns. ATLAS-JET data . . .

WELL FLOW INDEX	**1.6**
CLEAN HOLE DEPTH	**10"**
HOLE DIAMETER	**0.60"**

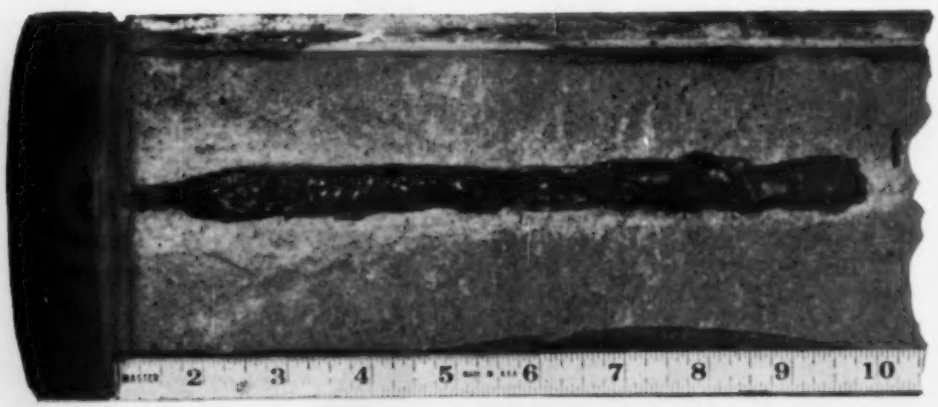
These tests were conducted independently of PGAC, with all targets and lab flow data complying with the proposed API standards for perforator evaluation.

Upon request, PGAC field engineers will gladly show you the complete test data – proof of the superiority of the new ATLAS-JET charges now available for 4" and 5" o.d. jet guns.

PGAC-597



Actual-size photo of entrance hole through face-plate of test at right



Test result with ½" s.o. in fluid: W.F.I. 1.6; Probe Depth 10"; Hole Diam. 0.60"

PGAC OIL FIELD SERVICES

Pan Geo Atlas Corp.

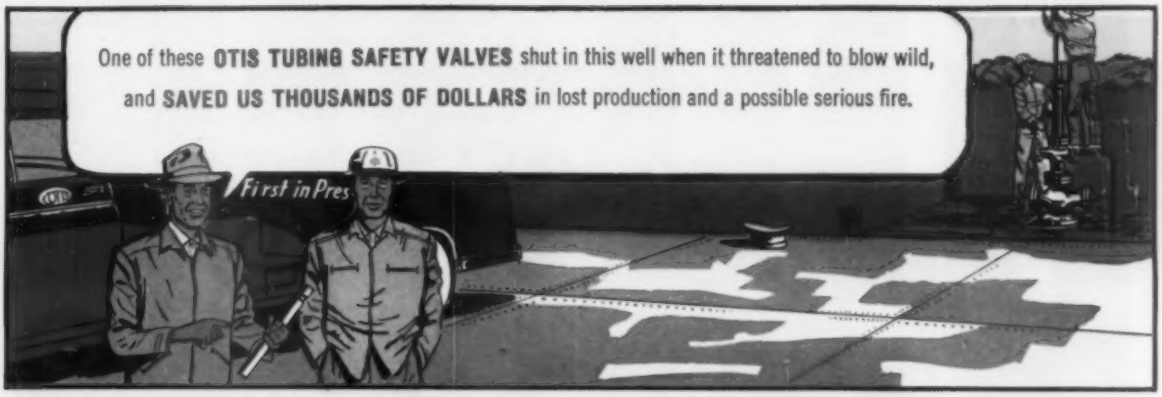
7730 Scott Street, Houston 21, Texas—Phone REpublic 4-1651

CHEMETRON

FORMERLY: PERFORATING GUNS ATLAS CORPORATION

PGAC's SUBSIDIARY COMPANIES — CANADA – Perforating Guns of Canada, Ltd. VENEZUELA and BOLIVIA – Servicios Tecnicos Atlas, C.A. GERMANY – Atlas Deutsch-Amerikanische Oilfelddienst, G.m.b.H. U.S.A. – PGAC Development Company

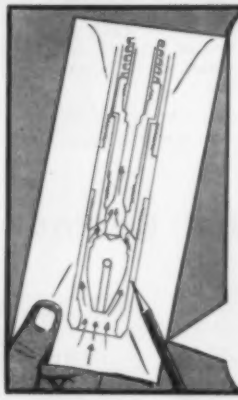
One of these **OTIS TUBING SAFETY VALVES** shut in this well when it threatened to blow wild, and **SAVED US THOUSANDS OF DOLLARS** in lost production and a possible serious fire.



The well was producing 2½ M.M.C.F.D. of gas with 89 B.D. of sand-laden oil when a leak developed at the flange of the master valve. At the time, the flowing pressure was 3,100 P.S.I., so it didn't take long for the gas and sand to cut out a sizable hole. As soon as the pressure differential exceeded the setting of the Otis Storm Choke®, it automatically snapped shut.

This morning we pumped down through the safety valve and killed the well with water—then broke out the master valve to repair the leaky connection. Now we're resetting the tree. We called out Otis to pull, check, and redress the safety valve before we put the well back on production. The valve's probably O.K., but it's been down there 10 months and under our safety program we pull all of our safety valves periodically for inspection anyway.

We just pulled the Storm Choke from this well and, although it has had heavily sand-laden fluid produced through it for the past 10 months, the bean is hardly flow-cut. The valve is one of our Type F valves, which we originally set for this customer. We've replaced the bean, redressed the valve, checked the setting, and are in the process of rerunning it. Our Type F valve is a spring-loaded valve that snaps closed when pressure, created by an increased flow through the valve, exceeds the compression setting of the valve spring.



In the opened position, flow through the valve follows a single, straight course. The valve is designed so that the sealing surfaces of the valve, and the valve seat, are out of the direct line of flow to minimize possible cutting action of the fluid. Although our tubing safety valves are pressure-differentially-operated, they will not close prematurely due to surging heads—and they can be adjusted to operate dependably within a very close range.

Otis Tubing Safety Valves, or Storm Chokes as they've been called for years, can be run in and landed under pressure in Otis nipples made up in the tubing string, or set in the tubing on slips for wells without nipples. OTIS TUBING SAFETY VALVES, SET BY OTIS CREWS, HAVE NEVER FAILED TO SHUT IN A BLOWOUT. Call the Otis office nearest you and talk to them about installing tubing safety valves—before you need them. A small investment in an Otis Storm Choke today can protect you against a possible fire or wild well tomorrow. PLAY IT SAFE WITH A SAFETY PROGRAM—CALL OTIS!

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Delayed action on distress signals for wire rope can set up a chain reaction of down-time losses.

With hundreds of selected distributors surrounding a hard core of 15 strategically located and expertly staffed branch offices and warehouses Union is uniquely organized for quick rescue service.

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Customers tell us Union's preventive service, coupled with quality so good it makes Union the ultimate low cost rope, is helping substantially to battle against rising operating costs.

Here's how customers have benefited in other ways from Union's years of preventive service. Union engineers sometimes found it impossible to select exactly the right rope from 1600 constructions in day to day production. To correct such a situation in the oil industry, Union engineers, working in the field with rig operators, and Union laboratory technicians developed an entirely new wire rope construction for rotary rig operation. Tailored into Tuffy Rotary line is a balance of strength, toughness and flexibility that has met every challenge including grueling service in drilling the world's deepest oil well.

"Ton-Mile" Engineered **Tuffy** Rotary Lines

Tuffy Standard Rotary Line is "ton-mile" engineered for standard and for large jackknife rotary rigs. Tuffy Jackknife Rotary Line is for drilling to depths up to 6,000 feet with the smaller jackknife rigs.

Union Wire Ropes For Well Servicing

For ultimate low-cost servicing ropes Union rod and tube pulling lines, rod hanger line, sand and pump line, cable tool drilling line and winch line.

Helicopters, long noted for their disaster missions, are becoming "work horses" in the air. Equipped with wire rope and slings they pick up and set materials and machinery down in inaccessible places and carry hurry up loads to otherwise easy to get to places. Photo courtesy Bell Helicopter Corporation, Ft. Worth, Texas.

Worldwide Distribution . . . Not far from wherever you produce or seek oil you'll find Tuffy Rotary Line and standard Union Well Servicing Ropes. You get service on schedule and the ultimate low cost wire ropes at leading oil field supply stores.

Ton Mile Indicator

This slide chart provides you a quick, easy method of figuring ton-miles in following the cut-off practice originally developed by Union engineers. Write Union Wire Rope Corporation, 2106 Manchester Ave., Kansas City 26, Mo.

Tuffy. Wire Rope Tips

Money-Saving Ideas on the Use and Care of Wire Rope

How to Check Groove Diameter

Not Quite — Just Right

Groove diameter of a sheave or drum must never be less than the actual calipered diameter of the new rope. When a new rope is installed on old equipment, use a reliable groove gauge to make sure the tread or bearing surface of all sheaves is of sufficient size to avoid pinching the rope.

Recommended Sizes

Diameter of Rope	Min. Dia.	Max. Dia.
¼ - 5/16	+ 1/64"	+ 1/32"
3/8 - 7/16	+ 1/32"	+ 1/16"
1/2 - 1 1/8	+ 3/64"	+ 3/32"
1 1/4 - 1 1/2	+ 1/16"	+ 1/8"
1 5/8 - 2 1/4	+ 3/32"	+ 5/32"
2 3/4 and larger	+ 1/8"	+ 1/4"

New ropes are usually oversize. It is advisable to have groove diameters of sheaves or drums as large as the actual calipered diameter of the new rope, or slightly larger.

Use the Right Fittings

Right fittings add life expectancy to wire rope. Fittings which derive holding power from crimping action are harmful. Shown here is a clamp that has no "wrong side"—can be put on either way. It snugly saddles the rope, grips larger surfaces in such a way that loads are carried almost entirely by friction instead of crimping action. Combined in its two parts is a thimble. The parts are interlocked to prevent collapse of the thimble, and eliminate all shear on the bolts.

Would you like a copy of a booklet in which more than a score of Tuffy Tips like these above are reproduced. If so, write Union Wire Rope Corporation, 2106 Manchester Ave., Kansas City 26, Missouri.

UNION Wire Rope

4-O

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OTHER SUBSIDIARIES AND DIVISIONS: Armco Division • Sheffield Division • The National Supply Company
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This is the new Baker Snap-Set Dual Packer

that is proving in hundreds of wells its ability to make dual-string hookups practical and reliable

To make a dual-string hookup work, you must have a dual packer that works—one that packs off and holds. Nothing defeats the economics of a dual completion like a packer that fails to set or one that leaks.

Here is a dual packer that does offer a positive and dependable packoff. It works and works well.

It is not only reliable, it is also easy to operate. You set down weight to packoff, pull up to release. Do it as many times as required for testing, spacing out or displacing.

A Baker Snap-Set Dual Packer does all the things a dual packer must do to make dual strings practical—and it does them simply and reliably.

LEFT: BAKER RETRIEVABLE SNAP-SET DUAL PACKER
It comes in two models. Model J (Product 756-J) is long-string set. Model K (Product 756-K) is short-string set. The picture shows a double-grip Model J.

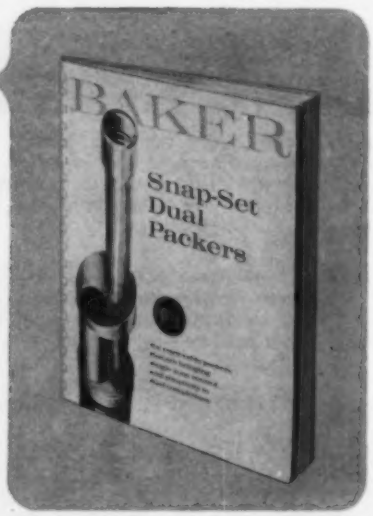
This is the new booklet that gives you the facts

Get it from a Baker man or send for it (see right)

In 52-pages—and with big pictures and few words—this informative new booklet gives you a perspective on dual completions. It also tells you the interesting engineering story behind this important new dual packer.

Here, in brief, are things the booklet talks about:

- Why dual-zone production (or injection) makes sense.
- A look at tubing and annulus completions.
- The importance of dual-string completions.
- Why a modern Baker dual-string hookup is so simple and practical.
- The seven things that make a good upper retrievable dual packer.
- The high cost of packer failures and how Baker Duals help avoid them.
- Review of an incredible series of performance and strength tests on the new Baker Snap-Set Duals.
- A review of remarkable field reports.
- How the Baker Field Service Organization works with you and stands behind every packer.
- Step-by-step schematics showing how to make Baker dual-string hookups.
- Hookup diagrams on the use of tail pipe; selective strings; selective multiples; dual-string injection; triple strings.



To get this new 52-page booklet, ask a Baker field man, or write to Baker Oil Tools, Inc., P.O. Box 2274, Terminal Annex, Los Angeles 54, California.

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BAKER OIL TOOLS, INC. HOUSTON/LOS ANGELES/NEW YORK

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A guide to . . .

job-rating a well for MINIMUM RIG HORSEPOWER in jet bit drilling

Ever wonder just how much horsepower it actually takes to drill a well using jet bit drilling practices? If your next well is one of the popular hole sizes, here's an easy, quick-to-use method which indicates minimum horsepower for pumping and hoisting

J. W. PERET
Sun Oil Company
Dallas, Texas

●

J. E. KASTROP
The Petroleum Engineer
Dallas, Texas

MINIMUM RIG HORSEPOWER requirements for pumping and hoisting can be calculated for a given hole size and given depth. The answers are based on acceptable conventional jet bit drilling practices and the calculations involved are those normally used when designing a good hydraulic program. This analysis is a different approach from normal practice where hydraulic and hoisting calculations are made for a given set of drilling conditions and known rig equipment capabilities.

But, how can you determine what the minimum rig horsepower needs will be for a given well before that well is drilled? The answer to this question is what we call *"Job-Rating"* a well. It is common practice in many industries to make an estimate of the number of man-hours required for a particular project before that project is undertaken. This is almost an engineered science in the process design field.

Why not such an estimate or job-rating for drilling a well? If there ever was a time when the industry needs to know just what it will take to drill a given well to a given depth before that well is actually drilled, that time is now. It is not necessary to use a ten-ton crane to lift a two-ton load. It is equally well known that a 20,000-ft rated drilling rig should not be used to drill a 5000-ft well; and, a 5000-ft rated rig should not be employed to drill a 20,000-ft well.

There is little disagreement on these broad principles. One is simply uneconomical; the other is unsafe, and probably won't do the job. But, there is still a broad spectrum where the relative values between job requirements and equipment capabilities become somewhat hazy, or the relationship is not well established. The problem has not been so much in hoisting as it has been in the area of hydraulics and the optimum utilization of mud pumps. We know a ten-ton crane can lift a two-ton load, and that a 20,000-ft rated rig can drill a 5000-ft well. But, while the job easily can be done, the economics are not in perspective.

A mud pump rated at 1000 hp (input) can provide 400 hhp output at the fluid end, but it does so by operating at only half its rated capacity. If the pump output requirements are known in advance of drilling the well, and this output has been carefully established as 400 hp, then it is not necessary (and is uneconomical) to employ a 1000-hp pump to do the job.

WHAT THESE TABLES SHOW

It is probable that when some experienced drilling men closely examine the tabulated results that follow and mentally compare the answers with their experience and practices, they will cast a jaundiced eye at these answers. It should be pointed out that nowhere in this project was the objective to rate a drilling rig or any of the component parts. The object was to establish in an acceptable engineering manner as accurately and as practical as possible **minimum horsepower requirements** for pumping and for hoisting. This has been done in accordance with acceptable jet bit drilling practices for the most popular hole and drill string sizes. A careful examination of the tabulated results in the five tables to follow should bring into focus a number of interesting and perhaps useful facts.

Effect of drill pipe size on pump size. Perhaps the most outstanding comparison shown is that of minimum hydraulic horsepower requirements at equivalent depths for various drill pipe sizes in a given hole size. It becomes quite apparent that adequate jet bit drilling can be accomplished with considerably less pump horsepower than normally applied . . . by the careful and engineered selection of the drill string. Of course, this selection must be balanced with the horsepower needed for hoisting, along with downhole conditions.

On Table 1-A, 1-B and 1-C, in the 6¾-in. hole, 2⅞-in. 10.4 lb per ft drill pipe was purposely selected to demonstrate the effect the drill string size has upon minimum hydraulic (and pump input) horsepower. At 7500 ft, minimum pump input horsepower to accomplish good jet bit drilling practices is 314 hp. Air weight of the drill string at this depth is 107,100 lb, and minimum drawworks input horsepower required is 417 hp.

By using 3½-in. by 13.3 lb per ft drill pipe, the minimum pump input horsepower drops to less than one-half, or 146 hp. The air weight of this drill string at 7500 ft is 127,100 lb and the calculated minimum drawworks input horsepower is 497 hp. We have reduced pump input horsepower by 53½% and increased hoisting horsepower requirements by only 19%.

Bit losses and total pressure losses. Another important comparison demonstrated in these tables is the relationship between pressure loss across the bit to total pressure losses

for the various drill string sizes in a given hole size. Again, the 2⅞-in. drill pipe in a 6¾-in. hole demonstrates this point quite clearly. And, it should be stated here that while the authors recognize that this small size drill pipe is not always used to drill a 6¾-in. hole, it was inserted in the tables primarily to demonstrate clearly some of the important points of this work.

It has been known for some time that best penetration rates in jet bit drilling are achieved when a large percentage of the total pressure drop is concentrated across the jet nozzles. Examine the column in Table 1-C under the heading of "Mud Pressure Losses (PSI) Through: Three Nozzle Jet Bit." The pressure drop across the bit at a given circulating rate and nozzle size is the same for any depth; it is the relationship of this bit drop to the total drop that changes with depth. For example, with a circulating rate of 180 gal per min to achieve an annular velocity of 119 ft per min and a nozzle velocity of 250 ft per sec, the drop across the bit is 563 psi. Total pressure drop at 5000 ft is 1792 psi, or the drop across the bit in this instance represents 31.4% of the total pressure drop. But, at 7500 ft, this pressure drop (563 psi) is only 23.5% of the total pressure drop (2391 psi).

Now, let's examine the same case by using 4-in. by 14.0 lb drill pipe, selected for illustrative purposes only, because of the close similarity of its stated annular and nozzle velocity with those in the above example. Here again, we maintain an annular velocity of 120 ft per min and a nozzle velocity of 258 ft per sec. Circulating rate is 150 gal per min, and the pressure drop across the bit is 597 psi. At 5000 ft, the total pressure drop is 856 psi. The drop across the bit represents 69.7% of the total pressure drop. At 7500 ft, the pressure drop across the bit is 63.8% of the total (936 psi).

This simple comparison should clearly indicate that not only should improved jet bit drilling be possible with larger drill pipe than with smaller drill pipe, but that much less pump horsepower is needed to accomplish this improvement.

In the above examples, substantially the same drop occurred across the 6¾-in. bit in all cases, yet a comparison based on drill string sizes reveals that input pump horsepower requirements for the 4-in. drill pipe is only 40% of that for 2⅞-in. at 5000 ft; and 32.7% at 7500 ft.

While this may well be a drastic comparison, the same investigation can be made on other drill pipe sizes to other depths and for other hole sizes as allowed by downhole conditions.

Undoubtedly, there are many other uses to which the data presented here can be put with good results. It is hoped that the industry will benefit in many ways from this study and it is also hoped that this information will be considered in the light of its objectives: **to place a minimum horsepower value on hydraulics and hoisting for acceptable jet bit drilling operations.**

BASIS FOR JOB-RATING CALCULATIONS

You might ask the question: "How can you calculate any horsepower requirements when you don't even know the hole size or how deep it's going to be?" "And, you also don't know what pump or pumps you're talking about . . . or, the drawworks, for that matter?" Of course, there must be some assumptions made before any answers are calculated. And, these assumptions must be as close to actual practice as possible and must be made with great care and consideration to the application of the answers. There is no attempt anywhere in this method whereby any item of rig equipment is rated. Rather, the approach here is to job-rate the well for minimum rig horsepower required to do the job according to the conditions selected for that job (hole size and well depth). We know for example that mud pumps are not always run at their rated capacity; neither are the engines that power these pumps. But, the values calculated for minimum hydraulic horsepower and for minimum pump input horsepower must be applied to fulfill the drilling conditions selected for each given job or well.

Hole Sizes

Anyone familiar with drilling recognizes that hole sizes vary all the way from 3¾-in. up to over 15 in. in diameter. What then, is the most practical approach in selecting hole sizes to consider? A survey of bit manufacturers and of operators indicated that the most popular sizes in the U. S. and Canada (and these sizes would possibly apply around the world) are: 6¾, 7⅞, 8¾ and 9⅞ in. It has been estimated that perhaps 75 to 80% of total footage drilled by rotary methods include the hole sizes shown above. There has been a definite trend in some active drilling areas toward more and deeper 12¼-in. holes. Because of this trend, the 12¼-in. hole size was added to the list, realizing that it is not a popular size in all areas. It was also learned that the most popular single hole size is the 8¾-in. Therefore, it appeared reasonable and practical to select these five different hole sizes for making the job-rating calculations.

Well Depths

While the "average" rotary-drilled well will "average" about 4300 ft deep, this average figure has little practical value when selecting well depths for these calculations. For practical reasons, three well depths were selected that appeared to be close to those drilled. These are: 5000 ft; 7500 ft; and 10,000 ft.

As it might well be expected, hydraulic horsepower and hook horsepower for the same drilling conditions when plotted against well depth are straight lines. To obtain horsepower requirements at any intermediate depth, or at any depth above or below these calculated depths, a straight-line extrapolation easily can be made. The slope of the line is not the same for different operating conditions (drill pipe size, mud circulating rate, bit weight, etc.). But, for the same operating conditions, horsepower values at different depths fall on a straight line. And, once this line has been established, other horsepower values can readily be determined for any desired depth.

For example: Fig. 1 is a plot of data from Table 3-B and 3-C. 3-B contains hoisting calculations for an 8¾-in. hole; while 3-C shows hydraulic data. For the purpose of this example, the calculated hydraulic horsepower and hook horsepower have been plotted for three depths (5000 ft, 7500 ft and 10,000 ft) using 4-in. EUE 14.00 lb per ft drill pipe. For all these depths, the calculated hydraulic horsepower values are based on a mud circulating rate of 300 gal per min, a nozzle velocity of 247 ft per sec; with three 13/32-in. nozzles, an annular return velocity of 120 ft per min, a 10-lb per gal mud, and a weight-on-bit of 39,200 lb (air weight of drill collars is 51,400 lb).

Should we desire to know what these minimum horsepower values would be at 9000 ft, a curve plotted as shown in Fig. 1 will provide the answer. At 9000 ft, hydraulic horsepower requirements are 233 hhp; and hook horsepower is 498 hp. From this straight line extrapolation, hy-

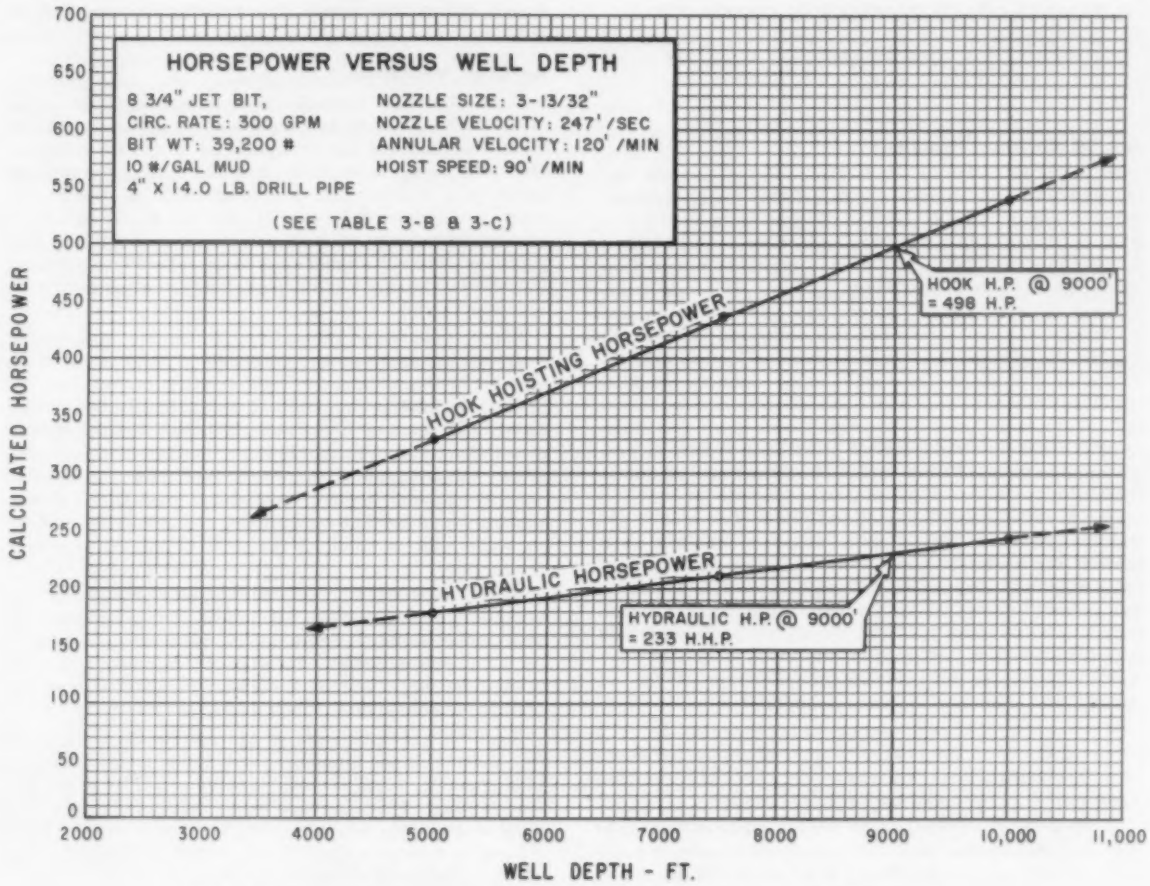

FIG. 1. **Horsepower for any depth** below, above or inbetween the depths given on the following tables can be determined by a simple straight-line extrapolation as shown above.

draulic and hook horsepower can be obtained for any depths below 5000 ft and for any greater than 10,000 ft by merely extending the curve in either direction and picking off the values corresponding to the desired depth. This method applies to all hole sizes considered on the following five tables.

Mud Weight

Hydraulic pressure drops throughout the mud system vary directly with the density of the fluid considered. To simplify these calculations, all values for pressure drops in the hydraulic tables have been calculated on the basis of a 10 lb per gal drilling fluid. This simplifies the matter of assigning corresponding pressure drops for the same system using a mud of greater or lesser density than 10 lb per gal.

As an example, suppose you wanted to know the hydraulic horsepower requirements in an 8¾-in. hole at 10,000 ft when using an 11.5 lb per gal mud. Drill pipe is 4-in. by 14.0 lb per ft. Circulating rate is 300 gal per min. Referring to Table 3-C, we find that the total pressure drop in the system for a 10 lb per gal mud is 1409 psi. To convert for 11.5 lb per gal mud, the following equation is used:

$$P_2 = P_1 \times \frac{\text{Desired Mud Weight}}{\text{Assumed Mud Weight}}$$

where,

P_2 = Pressure drop with desired mud weight, psi.

P_1 = Pressure drop with assumed mud weight, psi.

Assumed mud weight = 10 lb per gal.

Actual mud weight (in example above) = 11.5 lb per gal.

therefore,

$$P_2 = 1409 \text{ psi} \times \frac{11.5 \text{ lb/gal}}{10.0 \text{ lb/gal}}$$

P_2 = 1620 psi (total pressure drop)

To calculate the minimum hydraulic horsepower for the desired mud weight of 11.5 lb per gal, we use the formula:

$$\text{hhp} = \frac{G \times P}{1714}$$

where:

G = Circulating rate, gpm.

P = Total pressure drop, psi.

hhp = Hydraulic horsepower.

So, for an 11.5 lb per gal mud in the example cited,

$$\text{hhp} = \frac{300 \times 1620}{1714} = 283 \text{ hp}$$

Jet Bit Drilling Practices

In April 16, 1948, J. P. Nolley, George Cannon and Douglas Ragland, Humble Oil & Refining Company, presented a paper "The Relation of Nozzle Fluid Velocity to Rate of Penetration with Drag-Type Rotary Bits" before the Southwestern District, Division of Production, American Petroleum Institute at San Antonio, Texas. This report recognized the relationship between rate of penetration and bit horsepower, and established the concept of jet bit drilling. In the abstract, the authors state: "Observations recorded on 26 wells in Texas and Louisiana during the drilling of 106,800 ft of hole with 2-bladed drag-type bits show that, within wide limits of constant rotary speed and maximum effective bit weight, **rate of penetration is directly proportional to the product of rate of circulation and bit-nozzle fluid velocity.** Inasmuch as bit-nozzle fluid velocity may be varied at considerably less cost and power than rate of circulation, **maximum rates of penetration are obtained when most of the hydraulic horsepower, including that required for a reasonable flow in the drill pipe annulus, is converted into velocity energy at bit nozzles.** While these concepts were made for drag-type bits, the hydraulic concept still applies to our most modern rock bits which have been especially designed to take maximum advantage of the jet velocity idea expressed by these authors.

It is interesting to note from data presented in this API paper published in the *1948 Drilling and Producing Practices*, that penetration rates showed an appreciable increase when nozzle velocities exceeded 225 ft per sec.

Experience in various active drilling areas in the U. S. and Canada indicate maximum penetration rates are obtained when the nozzle velocity is set at established limits for that particular area. In West Texas, nozzle velocities of 250 to 275 ft per sec are common today; in the Gulf Coast of Louisiana, nozzle velocities are even higher, and some cases go up to 400 ft per sec. In the Mid-Continent and Rocky Mountains, nozzle velocities between 225 ft per sec and 250 ft per sec are common practice.

There is always a fallacy in attempting to apply "averages" to any actual case. However, in recognizing that the purpose of this tabulation is to indicate *minimums* rather than optimums, an average nozzle velocity of 250 ft per sec seemed most reasonable and practicable. However, since nozzle size for a given circulating rate is a function of nozzle velocity, the 250 ft per sec value was a "target value" and not an absolute value.

Nozzle velocities shown on the following tables occasionally exceed the 250 ft per sec "target" value in order to utilize an available nozzle size which would provide a nozzle velocity nearest to the target value. For example, at a circulating rate of 640 gal per min, three 5/8-in. nozzles give a nozzle velocity of 223 ft per sec . . . too far below our target value. So, we select three 9/16-in. nozzles to provide a nozzle velocity of 275 ft per sec. This value is closer to our target value for nozzle velocity . . . and, we also know from proven jet bit drilling practices that this higher nozzle velocity at the same circulating rate will put more hydraulic horsepower at the bit.

It is recognized at the outset that publication of Hughes Tool Company's bulletin No. 2-D *Hydraulics for Jet Bits*, revised June 1960, containing in tabular form answers to the basic equations used for calculating hydraulics greatly simplified this computation. These revised tables were heavily drawn upon for the data presented in the following tables.

Annular Velocities

Since the basic principle in jet bit drilling is to get as much of the available hydraulic horsepower at the bit, annular velocities are not as significant as nozzle velocities. However, it has been shown that the cutting-carrying capacity of a drilling fluid is a function of its density, viscosity and annular fluid velocity. Not too many years back, an annular velocity of 90 ft per min was considered good practices. Without a great deal of analytical investigations, the annular velocity was stepped up to 180 ft per min as the acceptable value.

Simple calculations showed that at this rate, considerable hydraulic horsepower was expended in most cases in the annulus without achieving the velocity energy idea expressed by Nolley, Cannon, and Ragland However, annular velocity for a given hole and drill pipe size does have a direct effect upon circulating rate . . . which in turn greatly effects the hydraulic horsepower. And, since no effective work is accomplished in the annulus, good jet bit drilling practices indicate that a circulating rate should be selected to accomplish as much of the work at the bit nozzles as practicable.

But . . . it is essential that the annular velocity be adequate to carry the cuttings off bottom as fast as these chips are cut by the bit. For this reason, the drilling industry is on a downward swing in its concept of annular velocities. And, today, more and more wells are being drilled at lower annular velocities than 150 ft per min.

Since we are attempting to concentrate the work at the bit, and not in the annulus . . . yet, must achieve adequate hole cleaning . . . an annular velocity near 120 ft per min was selected. This does not mean that annular velocities must exactly meet this value. But, the 120 ft per min figure was set as a target value . . . and actually achieved in many of the calculations shown on the tables to follow.

Drill Collars and Drill Pipe Sizes

Since the purpose of this tabulation is **not to design a drilling program but to establish minimum horsepower requirements,** drill collar length and size are important here only for calculating hoisting and hydraulic horsepower.

But, to make these data as practicable as possible, the size of drill collars selected were for the most part API sizes that could be washed over for fishing. Any variation from API recommended sizes was due to recent trends in popular drill collar sizes used in hole sizes studied. Once such a drill collar size was selected on the basis of API recommendations and upon popular usage, it was quickly recognized that a change to the next larger or smaller size would affect very little the total pressure loss in the hydraulic system. In most cases, a change to the next larger drill collar size would affect the total pressure drop less than 5%. And, since these calculations are for **minimum horsepower requirements,** it was not deemed necessary to include more than one drill collar size for a given hole size.

Length of drill collars was calculated only for the purpose of determining hydraulic losses and hoisting horsepower . . . and, not for designing a drilling program. There might be some disagreement about drill collar sizes and perhaps about length . . . but, it should be kept in mind that a nominal variation in both length and in diameter will not affect total hydraulic pressure losses more than 10%.

Once we have selected the desired drill collar size on which to base our calculations, it then becomes necessary

to determine drill collar length. Here, we get into weight on-bit practices. After considerable surveying of manufacturers' recommended bit weight for the various jet bit sizes, and comparing these recommendations with the most popular practices, it was decided to base drill collar length determinations upon the following bit weights:

Bit Sizes, in.	Weight on Bit, lb.
6¾	25,000
7⅞	30,000
8¾	40,000
9⅞	45,000
12¼	60,000

These bit weights are average values which consider manufacturer's recommendations and average field practice. However, we must recognize that drill collars are manufactured in 30-ft lengths, and these weights might have to be adjusted in our final calculations to account for the 30-ft lengths.

Effect of Buoyancy

If we are to place a predetermined weight on the bit with drilling fluid in the hole, we must take into account the effect of buoyancy on the actual air weight of the drill collars. Here's one simple way to consider the effect of buoyancy on steel drill collars. The weight of a cubic foot of steel is about 490 lb. A cubic foot of 10-lb-per-gal mud weighs about 75 lb. If the steel cube were emersed in this mud, it would weigh 75 lb less . . . or, 415 lb. So, the correction factor for buoyancy of steel in a 10-lb-per-gal mud is 490/415 = 1.18, meaning that for every 1000 lb of weight on bit needed in a 10-lb mud, 1180 lb (air weight) of drill collars must be provided.

The neutral point between compression and tension in the drill string should be located in the upper portion of the drill collars. Recommended practice is to locate this neutral point about 10% of the drill collar length from the top. What this actually means is that 90% of the length (and buoyant weight) of the drill collars represents weight on the bit.

To calculate drill collar length when we know its size (and weight per foot) and we also know what the bit weight in a 10-lb-per-gal mud should be, the following formula is used:

$$L_{dc} = \frac{W_b \times 1.18}{0.90 \times w_{dc}}$$

where:

L_{dc} = Length of drill collar, ft.
W_b = Desired bit weight, lb.
w_{dc} = Drill collar weight, lb per ft in air.

In the case of the 8¾-in. hole, we have selected a bit weight of 40,000 lb. Collar size selected for this size hole is 6¾-in. OD by 2 13/16-in. ID. Weight in air is 101 lb per ft.

The calculated drill collar length is:

$$L_{dc} = \frac{40{,}000 \times 1.18}{0.90 \times 101} = 519 \text{ ft.}$$

To get number of 30-ft joints, 519/30 = 17.3 joints. So, we use an even number of joints . . . 17 . . . and the drill collar length becomes 17 × 30 = 510 ft. Air weight of 510 ft of 6¾-in. by 2 13/16-in. drill collars = 510 × 101 lb per ft = 51,500 lb.

By correcting for buoyancy in a 10 lb per gal mud and for locating the neutral point 10% of the length from the top of the collars, actual weight-on-bit will be:

$$W_b = \frac{51{,}500 \times 0.90}{1.18} = 39{,}200 \text{ lb}$$

Nozzle Sizes and Number

Although it is possible through the use of two nozzles in a three-nozzle bit, or by using different nozzle sizes in all three nozzles, to obtain almost exactly a predetermined nozzle velocity, for all practical purposes, these calculations were based on using three nozzles of equal sizes. The size selected was dictated by commercially available sizes that provide the nearest nozzle velocity to the target velocity of 250 ft per min.

HYDRAULIC HORSEPOWER CALCULATIONS

The procedure for calculating **minimum hydraulic horsepower requirements** for a given hole size and for a given drill string follows closely the conventional procedure for such determinations. To demonstrate how the data presented in the following tables were obtained, a sample will be given. As outlined above, we have already calculated the length of drill collars to be used in an 8¾-in. hole. For the purpose of this example, we will refer to Table 3-C. Assume we want to use 4½-in. OD EUE 16.6 lb per ft drill pipe with internal flush tool joints to calculate minimum hydraulic horsepower needs.

Circulating Rate

As stated previously, our "target" annular and nozzle velocities are 120 ft per min and 250 ft per sec respectively. Referring to Hughes Tool Company Bulletin No. 2-D, page 6, we find that in an 8¾-in. hole with 4½-in. OD drill pipe, an annular velocity of 120 ft per min requires a circulating rate of 280 gal per min.

Nozzle Velocity

To determine what nozzle velocity we can get from such a circulating rate, we refer to page 16 of Bulletin 2-D. At a circulating rate of 280 gpm, three ⅜-in. nozzles will give us a nozzle velocity of 270 ft per sec . . . close to our target figure.

Mud Pressure Losses in System

Surface connections. Again referring to Hughes Tool Company Bulletin No. 2-D, page 20, we find that at 280 gpm, surface connection losses are 22 psi for Case 2. On page 19, Case 2 is described as consisting of the following: 40 ft of 3½-in. ID standpipe; 55 ft of 2½-in. ID rotary hose; 5 ft of 2½-in. ID swivel; and 40 ft of 3½-in. ID kelly. Case 1 showing the greatest pressure losses would only amount to 67 psi for 280 gpm . . . so the difference is negligible on the total losses. And, Case 2 would probably better describe what is used in actual practice.

Drill pipe losses. For 280 gpm, from page 24, and 4½-in. by 16.6 lb per ft drill pipe with I.F. tool joints the **internal pressure loss** is 32 psi per 1000 ft of drill pipe. Annular pressure losses shown on page 55 indicate that for the example case, at 280 gpm, the pressure drop is 6 psi per 1000 ft. The combined pressure drop for the drill pipe . . . inside and outside . . . is 32 + 6 = 38 psi per 1000 ft.

Drill collar losses. Page 32 of Bulletin 2-D shows an internal loss of 14.5 psi per 100 ft of drill collars with an ID of 2 13/16-in. at a circulating rate of 280 gpm. (It was necessary to interpolate between the tabulated loss for a

2⅞-in. bore and a 2¾-in. bore on page 32 of Bulletin 2-D.) For 510 ft of collars, inside loss is 14.5 × 5.10 = 74 psi. From page 44, pressure drop outside the drill collar is estimated at 4 psi per 100 ft for 280 gpm. Pressure drop around 510 ft of 6¾-in. drill collars = 4 × 5.10 = 20.4 or 20 psi.

Drop across bit nozzles. At 280 gpm, pressure drop across all three nozzles of ⅜-in. diam is shown on page 36 of Bulletin 2-D at 657 psi.

Constant pressure losses at 7500 ft. Constant pressure losses in this system at 280 gpm, regardless of depth, are:

TABLE 1-A SUMMARY DATA SHEET — HOLE SIZE 6¾" — **MINIMUM RIG HORSEPOWER REQUIREMENTS** (FOR TOTAL DEPTHS SHOWN)

TOTAL WELL DEPTH FEET	DRILL COLLAR SIZE O.D.-I.D. INCHES	DRILL PIPE SIZE O.D.-LBS/FT.	PUMP INPUT HORSEPOWER @ T.D. (1)	PUMP ENGINE RATED (2) HORSEPOWER	DRAW WORKS INPUT HORSEPOWER FROM T.D. (3)	DRAW WORKS ENGINE RATED (4) HORSEPOWER
5000′	5 X 2 1/4	2 7/8" X 10.4 (I.F.)	236	336	312	390
	5 X 2 1/4	3 1/2" X 13.3 (I.F.)	128	182	361	451
	5 X 2 1/4	4" X 14.0 (I.F.)	94	134	391	489
7500′	5 X 2 1/4	2 7/8" X 10.4 (I.F.)	314	448	417	522
	5 X 2 1/4	3 1/2" X 13.3 (I.F.)	146	204	497	620
	5 X 2 1/4	4" X 14.0 (I.F.)	102	147	543	678
10,000′	5 X 2 1/4	2 7/8" X 10.4 (I.F.)	392	560	523	654
	5 X 2 1/4	3 1/2" X 13.3 (I.F.)	164	235	630	787
	5 X 2 1/4	4" X 14.0 (I.F.)	111	159	692	864

(1) FOR VOLUMETRIC AND TRANSMISSION LOSSES = 20%
(2) FOR TRANSMISSION LOSSES AND DIFFERENCE FROM ACTUAL = 30%

TABLE 1-C HYDRAULIC DATA SHEET — HOLE SIZE 6¾" — **CALCULATED MINIMUM**

DRILL COLLAR SIZE O.D.-I.D.	DRILL PIPE SIZE O.D.LBS/FT	MUD CIRCULATING RATE G.P.M.	ANNULAR RETURN VELOCITY FT/MIN.	JET BIT NOZZLE VELOCITY FT/SEC.	NOZZLE SIZE — 3 PER BIT INCH	MUD PRESSURE		
						SURFACE CONNECTIONS	DRILL PIPE PER 1000 FT.	
							INSIDE	OUTSIDE
5"X 2 1/4"	27/8"X10.4 (I.F.)	180	119	250	5/16	29	232	8
5"X 2 1/4"	31/2"X13.3 (I.F.)	160	120	275	9/32	24	56	7
5"X 2 1/4"	4" X 14.0 (I.F.)	150	120	258	9/32	8	20	14

Surface connections	22 psi
Inside drill collars	74 psi
Outside drill collars	20 psi
Across 3-nozzle bit	657 psi
Total constant drops	773 psi

Drill pipe losses at 7500 ft total depth. Subtracting 510 ft of drill collars, we get 6990 ft of drill pipe. Since drill pipe losses, both inside and outside amounted to 38 psi per 1000 ft of length, we multiply 6.99 by 38 = 265 psi.

Total pressure losses at 7500 ft total depth = constant pressure losses plus pressure drop inside and outside the drill

TABLE 1-B — HOISTING DATA SHEET
MINIMUM HOOK HORSEPOWER

WEIGHT OF DRILL STRING IN AIR-LBS. (FOR T.D.)	CALCULATED HOOK HORSEPOWER @ 90 FT/MIN. (FROM T.D.)
79,900	218
92,600	252
100,500	274
107,100	292
127,100	348
139,600	380
134,300	367
161,700	441
177,700	485

BASIS FOR CALCULATIONS

1. NOZZLE VELOCITY TO BE HELD NEAR 250 FT/SEC.
2. ANNULAR RETURN VELOCITY TO BE HELD NEAR 120 FT/MIN.
3. MUD WEIGHT = 10 LBS/GAL.
4. BIT WEIGHT USED TO CALCULATE DRILL COLLAR LENGTH = 24,337 LBS. NEUTRAL POINT BETWEEN TENSION AND COMPRESSION LOCATED 10 PERCENT OF LENGTH FROM TOP.
5. DRILL COLLAR SIZE SELECTED ON BASIS OF PROVIDING ADEQUATE CLEARANCE FOR WASH-OVER SHOE. TO CALCULATE HYDRAULIC LOSSES ONLY.
6. BASED ON ACCEPTABLE JET BIT DRILLING PRACTICES AND PRINCIPLES.
7. FOR THREE NOZZLES OF EQUAL SIZE.

(3) FOR SHEAVE AND TRANSMISSION LOSSES = 30%
(4) FOR TRANSMISSION LOSSES AND DIFFERENCE FROM ACTUAL = 20%

HYDRAULIC HORSEPOWER REQUIREMENTS

LOSSES (PSI) THROUGH:			TOTAL PRESSURE LOSSES (SURFACE PUMP PRESS-PSI) AT TOTAL DEPTH			HYDRAULIC HORSEPOWER REQUIREMENTS (PUMP OUTPUT)		
DRILL COLLARS 600 FT.		THREE NOZZLE JET BIT						
INSIDE	OUTSIDE		5000′	7500′	10,000′	5000′	7500′	10,000′
114	30	563	1792	2391	2991	188	251	312
90	24	679	1094	1251	1410	102	117	132
78	18	597	856	936	1021	75	82	89

pipe. This is 773 + 265 = 1038 psi.

Hydraulic Horsepower

For this value, we use the hydraulic horsepower formula:

$$\text{hhp} = \frac{G \times P}{1714}$$

where,

G = Circulating rate, gal per min
P = Total pressure drop, psi

For the example case, where P = 1038 psi at 280 gpm,

$$\text{hhp} = \frac{280 \times 1038}{1714} = 169.5 \text{ or } 170 \text{ hp.}$$

TABLE 2-A SUMMARY DATA SHEET HOLE SIZE 7 7/8" — **MINIMUM RIG HORSEPOWER REQUIREMENTS** (FOR TOTAL DEPTHS SHOWN)

TOTAL WELL DEPTH FEET	DRILL COLLAR SIZE O.D.-I.D. INCHES	DRILL PIPE SIZE O.D.-LBS/FT.	PUMP INPUT HORSEPOWER @ T.D. (1)	PUMP ENGINE RATED (2) HORSEPOWER	DRAW WORKS INPUT HORSEPOWER FROM T.D. (3)	DRAW WORKS ENGINE RATED (4) HORSEPOWER
5000′	5 3/4 X 2 13/16	3 1/2" X 13.3 (I. F.)	204	292	387	483
	5 3/4 X 2 13/16	4" X 14.0 (I. F.)	137	196	419	524
	5 3/4 X 2 13/16	4 1/2" X 16.6 (I. F.)	126	180	454	569
7500′	5 3/4 X 2 13/16	3 1/2" X 13.3 (I. F.)	251	359	521	651
	5 3/4 X 2 13/16	4" X 14.0 (I. F.)	156	223	570	712
	5 3/4 X 2 13/16	4 1/2" X 16.6 (I. F.)	138	197	631	788
10,000′	5 3/4 X 2 13/16	3 1/2" X 13.3 (I. F.)	298	341	656	820
	5 3/4 X 2 13/16	4" X 14.0 (I. F.)	174	249	722	901
	5 3/4 X 2 13/16	4 1/2" X 16.6 (I. F.)	150	214	800	1,000

(1) FOR VOLUMETRIC AND TRANSMISSION LOSSES = 20%
(2) FOR TRANSMISSION LOSSES AND DIFFERENCE FROM ACTUAL = 30%

TABLE 2-C HYDRAULIC DATA SHEET HOLE SIZE 7 7/8" — **CALCULATED MINIMUM**

DRILL COLLAR SIZE O.D.-I.D.	DRILL PIPE SIZE O.D.LBS/FT	MUD CIRCULATING RATE G.P.M.	ANNULAR RETURN VELOCITY FT/MIN.	JET BIT NOZZLE VELOCITY FT/SEC.	NOZZLE SIZE — 3 PER BIT INCH	MUD PRESSURE		
						SURFACE CONNECTIONS	DRILL PIPE PER 1000 FT.	
							INSIDE	OUTSIDE
5 3/4" X 2 13/16"	3 1/2" X 13.3 (I. F.)	230	115	265	11/32	10	109	4
5 3/4" X 2 13/16"	4" X 14.0 (I. F.)	220	115	253	11/32	9	40	6
5 3/4" X 2 13/16"	4 1/2" X 16.6 (I. F.)	220	130	253	11/32	9	21	9

HORSEPOWER LOSSES

Mud Pump Input

Efficiency measurements in the fluid end of a mud pump show relatively high values . . . as much as 95%. This volumetric efficiency varies with pump speed and discharge pressure. And, when it is considered that the more exacting volumetric efficiency measurements have been made under better-than-average-conditions, it would be reasonable to assume that volumetric efficiencies attained in the field are not as high as those measured under controlled conditions.

But, volumetric efficiency is not the only factor affecting the overall power losses through a mud pump. Before power

TABLE 2-B — HOISTING DATA SHEET
MINIMUM HOOK HORSEPOWER

WEIGHT OF DRILL STRING IN AIR-LBS. (FOR T.D.)	CALCULATED HOOK HORSEPOWER @ 90 FT/MIN. (FROM T.D.)
99,400	271
107,300	293
116,800	318
133,900	365
146,300	399
161,800	441
168,300	459
185,300	505
205,100	560

BASIS FOR CALCULATIONS

1. NOZZLE VELOCITY TO BE HELD NEAR 250 FT/SEC.
2. ANNULAR RETURN VELOCITY TO BE HELD NEAR 120 FT/MIN.
3. MUD WEIGHT = 10 LBS/GAL.
4. BIT WEIGHT USED TO CALCULATE DRILL COLLAR LENGTH = 29,000 LBS. NEUTRAL POINT BETWEEN TENSION AND COMPRESSION LOCATED 10 PERCENT OF LENGTH FROM TOP.
5. DRILL COLLAR SIZE SELECTED ON BASIS OF PROVIDING ADEQUATE CLEARANCE FOR WASH-OVER SHOE. TO CALCULATE HYDRAULIC LOSSES ONLY.
6. BASED ON ACCEPTABLE JET BIT DRILLING PRACTICES AND PRINCIPLES.
7. FOR THREE NOZZLES OF EQUAL SIZE.

(3) FOR SHEAVE AND TRANSMISSION LOSSES = 30%
(4) FOR TRANSMISSION LOSSES AND DIFFERENCE FROM ACTUAL = 20%

HYDRAULIC HORSEPOWER REQUIREMENTS

LOSSES (PSI) THROUGH: DRILL COLLARS 570 FT.		THREE NOZZLE JET BIT	TOTAL PRESSURE LOSSES (SURFACE PUMP PRESS-PSI) AT TOTAL DEPTH			HYDRAULIC HORSEPOWER REQUIREMENTS (PUMP OUTPUT)		
INSIDE	OUTSIDE		5000′	7500′	10,000′	5000′	7500′	10,000′
57	18	629	1,215	1,497	1,779	163	201	238
51	18	575	857	972	1,087	110	125	139
51	18	575	786	857	936	101	110	120

is applied at the fluid end, shafts and gears must be turned. Recognizing that the loss in the pump's transmission is relatively small, when we combine the volumetric loss with the transmission loss for a majority of the mud pumps used in drilling, an overall loss of 20% may be considered typical.

For the sake of calculating mud pump input horsepower requirements, and not for the sake of rating mud pumps, an efficiency factor of 80% is used. Therefore, hydraulic horsepower is divided by 0.80 to tell us what are the minimum pump input horsepower requirements.

Between the mud pump input and the rated horsepower of the mud pump engine, there are a number of power loss

TABLE 3-A SUMMARY DATA SHEET — HOLE SIZE 8 3/4" — **MINIMUM RIG HORSEPOWER REQUIREMENTS** (FOR TOTAL DEPTHS SHOWN)

TOTAL WELL DEPTH FEET	DRILL COLLAR SIZE O.D.-I.D. INCHES	DRILL PIPE SIZE O.D.-LBS/FT.	PUMP INPUT HORSEPOWER @ T.D. (1)	PUMP ENGINE RATED (2) HORSEPOWER	DRAW WORKS INPUT HORSEPOWER FROM T.D. (3)	DRAW WORKS ENGINE RATED (4) HORSEPOWER
5000′	6 3/4 X 2 13/16	4" X 14.0 (I.F.)	225	322	475	592
	6 3/4 X 2 13/16	4 1/2" X 16.6 (I.F.)	193	276	510	637
	6 3/4 X 2 13/16	5" X 19.5 (X H)	146	209	561	700
7500′	6 3/4 X 2 13/16	4" X 14.0 (I.F.)	267	382	626	783
	6 3/4 X 2 13/16	4 1/2" X 16.6 (I.F.)	212	303	682	851
	6 3/4 X 2 13/16	5" X 19.5 (X H)	158	225	760	950
10,000′	6 3/4 X 2 13/16	4" X 14.0 (I.F.)	308	440	780	975
	6 3/4 X 2 13/16	4 1/2" X 16.6 (I.F.)	231	330	858	1,071
	6 3/4 X 2 13/16	5" X 19.5 (X H)	169	241	961	1,200

(1) FOR VOLUMETRIC AND TRANSMISSION LOSSES = 20%
(2) FOR TRANSMISSION LOSSES AND DIFFERENCE FROM ACTUAL = 30%

TABLE 3-C HYDRAULIC DATA SHEET — HOLE SIZE 8 3/4" — **CALCULATED MINIMUM**

DRILL COLLAR SIZE O.D.-I.D.	DRILL PIPE SIZE O.D.LBS/FT	MUD CIRCULATING RATE G.P.M.	ANNULAR RETURN VELOCITY FT/MIN.	JET BIT NOZZLE VELOCITY FT/SEC.	NOZZLE SIZE — 3 PER BIT INCH	MUD PRESSURE		
						SURFACE CONNECTIONS	DRILL PIPE PER 1000 FT.	
							INSIDE	OUTSIDE
6 3/4" X 2 13/16"	4" X 14.0 (I.F.)	300	120	247	13/32	26	71	5
6 3/4" X 2 13/16"	4 1/2" X16.6 (I.F.)	280	120	270	3/8	22	32	6
6 3/4" X 2 13/16"	5" X 19.5 (X H)	260	125	251	3/8	19	17	6

factors to consider. First is the type of power transmission system. For most mud pumps in drilling service, the belt drive is the most popular. Surprisingly enough, the horsepower loss from driving sheave to driven sheave is quite low. The driving sheave may be attached to the clutch shaft mounted on the pump engine. Or, the pump may be driven by a sheave off the power compound from the drawworks engine. There may be torque converters, hydraulic couplings and electric power.

A second factor to consider is the difference between the rated horsepower output of an internal combustion engine (in new condition and operating at sea level) and

TABLE 3-B — HOISTING DATA SHEET
MINIMUM HOOK HORSEPOWER

WEIGHT OF DRILL STRING IN AIR-LBS. (FOR T.D.)	CALCULATED HOOK HORSEPOWER @ 90 FT/MIN. (FROM T.D.)
121,400	332
130,900	357
143,900	392
160,400	438
174,900	477
195,100	532
199,400	545
219,400	600
246,100	672

BASIS FOR CALCULATIONS

1. NOZZLE VELOCITY TO BE HELD NEAR 250 FT/SEC.
2. ANNULAR RETURN VELOCITY TO BE HELD NEAR 120 FT/MIN.
3. MUD WEIGHT = 10 LBS/GAL.
4. BIT WEIGHT USED TO CALCULATE DRILL COLLAR LENGTH = 39,200 LBS. NEUTRAL POINT BETWEEN TENSION AND COMPRESSION LOCATED 10 PERCENT OF LENGTH FROM TOP.
5. DRILL COLLAR SIZE SELECTED ON BASIS OF PROVIDING ADEQUATE CLEARANCE FOR WASH-OVER SHOE. TO CALCULATE HYDRAULIC LOSSES ONLY.
6. BASED ON ACCEPTABLE JET BIT DRILLING PRACTICES AND PRINCIPLES.
7. FOR THREE NOZZLES OF EQUAL SIZE.

(3) FOR SHEAVE AND TRANSMISSION LOSSES = 30%
(4) FOR TRANSMISSION LOSSES AND DIFFERENCE FROM ACTUAL = 20%

HYDRAULIC HORSEPOWER REQUIREMENTS

LOSSES (PSI) THROUGH:			TOTAL PRESSURE LOSSES (SURFACE PUMP PRESS-PSI) AT TOTAL DEPTH			HYDRAULIC HORSEPOWER REQUIREMENTS (PUMP OUTPUT)		
DRILL COLLARS 510 FT.		THREE NOZZLE JET BIT						
INSIDE	OUTSIDE		5000′	7500′	10,000′	5000′	7500′	10,000′
87	26	549	1,029	1,219	1,409	180	213	246
74	20	657	943	1,038	1,134	155	170	185
66	20	567	775	833	890	117	126	135

the actual delivered horsepower during pumping operations. To include both factors, we have assumed a total of 30% difference between pump engine rating and actual horsepower delivered to the pump input shaft. The efficiency factor in this step is 70%. To arrive at a value for minimum rated engine horsepower, we divide the calculated mud pump input horsepower by 0.70. These losses through the mud pump and from mud pump input to pump engine rated horsepower are illustrated in Fig. 2.

Hoisting Horsepower

There is nothing new about calculating hook horsepower

TABLE 4-A SUMMARY DATA SHEET — HOLE SIZE 9 7/8" — **MINIMUM RIG HORSEPOWER REQUIREMENTS** (FOR TOTAL DEPTHS SHOWN)

TOTAL WELL DEPTH FEET	DRILL COLLAR SIZE O.D.-I.D. INCHES	DRILL PIPE SIZE O.D.-LBS/FT.	PUMP INPUT HORSEPOWER @ T.D. (1)	PUMP ENGINE RATED (2) HORSEPOWER	DRAW WORKS INPUT HORSEPOWER FROM T.D. (3)	DRAW WORKS ENGINE RATED (4) HORSEPOWER
5000′	7 3/4 X 2 13/16	4 1/2"X 16.6 (I.F.)	307	439	545	681
	7 3/4 X 2 13/16	5"X 19.5 (X.H.)	250	357	598	750
	7 3/4 X 2 13/16	5 1/2"X 21.9 (F.H.) (4"BORE)	212	303	657	822
7500′	7 3/4 X 2 13/16	4 1/2"X 16.6 (I.F.)	350	500	718	900
	7 3/4 X 2 13/16	5" X 19.5 (X.H.)	280	400	800	1,000
	7 3/4 X 2 13/16	5 1/2"X 21.9 (F.H.) (4"BORE)	224	320	892	1,112
10,000′	7 3/4 X 2 13/16	4 1/2"X 16.6 (I.F.)	392	561	892	1,112
	7 3/4 X 2 13/16	5"X 19.5 (X.H.)	306	437	1,000	1,245
	7 3/4 X 2 13/16	5 1/2"X 21.9 (F.H.) (4"BORE)	235	336	1,125	1,405

(1) FOR VOLUMETRIC AND TRANSMISSION LOSSES = 20%
(2) FOR TRANSMISSION LOSSES AND DIFFERENCE FROM ACTUAL = 30%

TABLE 4-C HYDRAULIC DATA SHEET — HOLE SIZE 9 7/8" — **CALCULATED MINIMUM**

DRILL COLLAR SIZE O.D.-I.D.	DRILL PIPE SIZE O.D.LBS/FT	MUD CIRCULATING RATE G.P.M.	ANNULAR RETURN VELOCITY FT/MIN.	JET BIT NOZZLE VELOCITY FT/SEC.	NOZZLE SIZE — 3 PER BIT INCH	MUD PRESSURE		
						SURFACE CONNECTIONS	DRILL PIPE PER 1000 FT.	
							INSIDE	OUTSIDE
7 3/4" X 2 13/16"	4 1/2"X 16.6 (I.F.)	380	120	270	7/16	43	57	4
7 3/4"X 2 13/16"	5" X 19.5 (X.H.)	360	120	255	7/16	39	32	4
7 3/4"X 2 13/16"	5 1/2"X 21.9 (F.H.)	330	120	271	13/32	32	16	3

once the weight of the drill string has been determined and the hoisting speed known. The popular formula is:

$$\text{Hook hp} = \frac{W_{ds} \times S}{33{,}000}$$

where,

W_{ds} = Weight of the drill string, lb.
S = Hoisting speed, ft per min.

For the purpose of these calculations, hoisting speed is assumed to be 90 ft per min. Some engineers use the figure

TABLE 4-B	HOISTING DATA SHEET **MINIMUM HOOK HORSEPOWER**
WEIGHT OF DRILL STRING IN AIR-LBS. (FOR T.D.)	CALCULATED HOOK HORSEPOWER @ 90 FT/MIN. (FROM T.D.)
139,700	382
153,200	418
168,500	460
183,700	502
204,600	559
228,500	624
228,500	624
256,000	700
288,500	787

BASIS FOR CALCULATIONS

1. NOZZLE VELOCITY TO BE HELD NEAR 250 FT/SEC.
2. ANNULAR RETURN VELOCITY TO BE HELD NEAR 120 FT/MIN.
3. MUD WEIGHT = 10 LBS/GAL.
4. BIT WEIGHT USED TO CALCULATE DRILL COLLAR LENGTH = 44,500 LBS. NEUTRAL POINT BETWEEN TENSION AND COMPRESSION LOCATED 10 PERCENT OF LENGTH FROM TOP.
5. DRILL COLLAR SIZE SELECTED ON BASIS OF PROVIDING ADEQUATE CLEARANCE FOR WASH-OVER SHOE. TO CALCULATE HYDRAULIC LOSSES ONLY.
6. BASED ON ACCEPTABLE JET BIT DRILLING PRACTICES AND PRINCIPLES.
7. FOR THREE NOZZLES OF EQUAL SIZE.

(3) FOR SHEAVE AND TRANSMISSION LOSSES = 30%
(4) FOR TRANSMISSION LOSSES AND DIFFERENCE FROM ACTUAL = 20%

HYDRAULIC HORSEPOWER REQUIREMENTS

LOSSES (PSI) THROUGH:			TOTAL PRESSURE LOSSES (SURFACE PUMP PRESS-PSI) AT TOTAL DEPTH			HYDRAULIC HORSEPOWER REQUIREMENTS (PUMP OUTPUT)		
DRILL COLLARS 420 FT.		THREE NOZZLE JET BIT						
INSIDE	OUTSIDE		5000′	7500′	10,000′	5000′	7500′	10,000′
109	21	654	1,107	1,260	1,412	245	279	313
93	21	587	951	1,066	1,162	200	224	244
80	17	664	880	928	975	169	179	188

of 100 ft per min, while others use 90 ft per min. Since we are primarily interested in **minimum horsepower,** the lower figure of 90 ft per min is used in these hook horsepower calculations.

Drill string weight used is that of the total weight of the entire drill string in air. The effect of buoyancy has been neglected, although it can be calculated for a given mud density. However, offsetting buoyancy is that of friction upon the drill string against the wall of the hole. This latter factor is difficult to determine in actual practice. It is usually acceptable in hook horsepower calculations to consider that

TABLE 5-A — SUMMARY DATA SHEET — HOLE SIZE 12¼" — **MINIMUM RIG HORSEPOWER REQUIREMENTS** (FOR TOTAL DEPTHS SHOWN)

TOTAL WELL DEPTH FEET	DRILL COLLAR SIZE O.D.-I.D. INCHES	DRILL PIPE SIZE O.D.-LBS/FT.	PUMP INPUT HORSEPOWER @ T.D. (1)	PUMP ENGINE RATED (2) HORSEPOWER	DRAW WORKS INPUT HORSEPOWER FROM T.D. (3)	DRAW WORKS ENGINE RATED (4) HORSEPOWER
5000′	8X3	4 1/2" X 16.6 (I.F.)	797	1,138	617	772
	8X3	5" X 19.5 (F.H.)	587	838	668	837
	8X3	5 1/2" X 21.9 (F.H.) (4" BORE)	472	675	727	910
7500′	8X3	4 1/2" X 16.6 (I.F.)	980	1,400	790	988
	8X3	5" X 19.5 (F.H.)	684	976	870	1,088
	8X3	5 1/2" X 21.9 (F.H.) (4" BORE)	524	749	964	1,202
10,000′	8X3	4 1/2" X 16.6 (I.F.)	1,153	1,649	964	1,202
	8X3	5" X 19.5 (F.H.)	780	1,112	1,072	1,342
	8X3	5 1/2" X 21.9 (F.H.) (4" BORE)	580	830	1,195	1,495

(1) FOR VOLUMETRIC AND TRANSMISSION LOSSES = 20%
(2) FOR TRANSMISSION LOSSES AND DIFFERENCE FROM ACTUAL = 30%

TABLE 5-C — HYDRAULIC DATA SHEET — HOLE SIZE 12¼" — **CALCULATED MINIMUM**

DRILL COLLAR SIZE O.D.-I.D.	DRILL PIPE SIZE O.D.LBS/FT	MUD CIRCULATING RATE G.P.M.	ANNULAR RETURN VELOCITY FT/MIN.	JET BIT NOZZLE VELOCITY FT/SEC.	NOZZLE SIZE — 3 PER BIT INCH	MUD PRESSURE		
						SURFACE CONNECTIONS	DRILL PIPE PER 1000 FT.	
							INSIDE	OUTSIDE
8" X 3"	4 1/2" X 16.6 (I.F.)	640	120	275	9/16	71	150	3
8" X 3"	5" X 19.5 (F.H.)	610	120	262	9/16	65	84	3
8" X 3"	5 1/2" X 21.9 (F.H.) (4" BORE)	590	120	253	9/16	61	48	3

from a practical view point, the effect of buoyancy is counteracted by the effect of wall friction. Therefore, for these hook horsepower calculations, only the air weight of the entire drill string is used.

As an example, consider what the hook horsepower would be when hoisting from an 8¾-in. hole at a total depth of 10,000 ft. Refer to Table 3-B, where 4½-in. by 16.6 lb per ft drill pipe is used with 510 ft of 6¾-in. OD by 2 13/16-in. ID drill collars. Total air weight of this string is 219,400 lb (Table 3-B). Using the hook horsepower formula:

TABLE 5-B — HOISTING DATA SHEET
MINIMUM HOOK HORSEPOWER

WEIGHT OF DRILL STRING IN AIR-LBS. (FOR T.D.)	CALCULATED HOOK HORSEPOWER @ 90 FT/MIN. (FROM T.D.)
158,500	432
171,500	467
186,600	508
202,500	553
222,900	607
246,600	674
246,700	674
274,500	750
306,900	837

BASIS FOR CALCULATIONS

1. NOZZLE VELOCITY TO BE HELD NEAR 250 FT/SEC.
2. ANNULAR RETURN VELOCITY TO BE HELD NEAR 120 FT/MIN.
3. MUD WEIGHT = 10 LBS/GAL.
4. BIT WEIGHT USED TO CALCULATE DRILL COLLAR LENGTH = 60,400LBS. NEUTRAL POINT BETWEEN TENSION AND COMPRESSION LOCATED 10 PERCENT OF LENGTH FROM TOP.
5. DRILL COLLAR SIZE SELECTED ON BASIS OF PROVIDING ADEQUATE CLEARANCE FOR WASH-OVER SHOE. TO CALCULATE HYDRAULIC LOSSES ONLY.
6. BASED ON ACCEPTABLE JET BIT DRILLING PRACTICES AND PRINCIPLES.
7. FOR THREE NOZZLES OF EQUAL SIZE.

(3) FOR SHEAVE AND TRANSMISSION LOSSES = 30%
(4) FOR TRANSMISSION LOSSES AND DIFFERENCE FROM ACTUAL = 20%

HYDRAULIC HORSEPOWER REQUIREMENTS

LOSSES (PSI) THROUGH:			TOTAL PRESSURE LOSSES (SURFACE PUMP PRESS-PSI) AT TOTAL DEPTH			HYDRAULIC HORSEPOWER REQUIREMENTS (PUMP OUTPUT)		
DRILL COLLARS 540 FT.		THREE NOZZLE JET BIT						
INSIDE	OUTSIDE		5000′	7500′	10,000′	5000′	7500′	10,000′
265	5	679	1,705	2,097	2,470	637	783	923
238	5	617	1,313	1,531	1,749	468	546	623
221	5	577	1,092	1,219	1,347	377	419	464

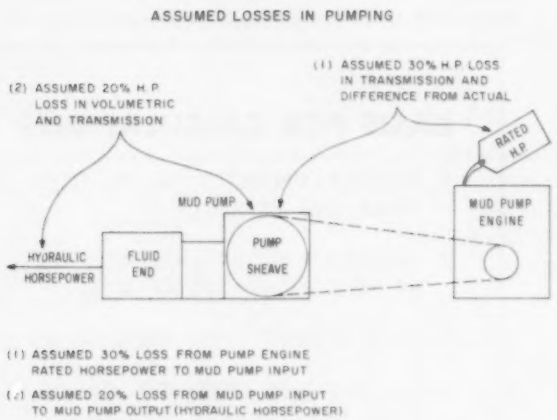
ASSUMED LOSSES IN PUMPING
(2) ASSUMED 20% H.P. LOSS IN VOLUMETRIC AND TRANSMISSION
(1) ASSUMED 30% H.P. LOSS IN TRANSMISSION AND DIFFERENCE FROM ACTUAL
RATED H.P.
MUD PUMP
MUD PUMP ENGINE
HYDRAULIC HORSEPOWER
FLUID END
PUMP SHEAVE
(1) ASSUMED 30% LOSS FROM PUMP ENGINE RATED HORSEPOWER TO MUD PUMP INPUT
(2) ASSUMED 20% LOSS FROM MUD PUMP INPUT TO MUD PUMP OUTPUT (HYDRAULIC HORSEPOWER)

FIG. 2. **Assumed losses in pumping** on which these calculations were based are illustrated by this diagram.

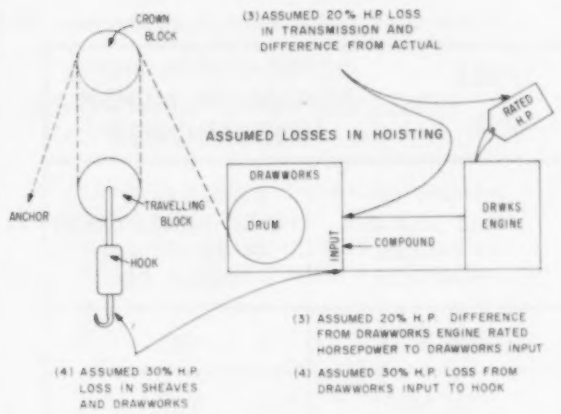
CROWN BLOCK
(3) ASSUMED 20% H.P. LOSS IN TRANSMISSION AND DIFFERENCE FROM ACTUAL
ASSUMED LOSSES IN HOISTING
RATED H.P.
DRAWWORKS
ANCHOR
TRAVELLING BLOCK
DRUM
DRWKS ENGINE
INPUT
COMPOUND
HOOK
(3) ASSUMED 20% H.P. DIFFERENCE FROM DRAWWORKS ENGINE RATED HORSEPOWER TO DRAWWORKS INPUT
(4) ASSUMED 30% H.P. LOSS IN SHEAVES AND DRAWWORKS
(4) ASSUMED 30% H.P. LOSS FROM DRAWWORKS INPUT TO HOOK

FIG. 3. **Assumed losses in hoisting system** for average rig operating under average drilling conditions.

$$\text{Hook hp} = \frac{219{,}400 \times 90.0}{33{,}000} = 600 \text{ hp.}$$

Drawworks Input Horsepower

Working backward to the drawworks input, we must assume certain losses. A critical analysis of the loss in the sheaves of the crown and travelling blocks indicate from 1.5 to 2.0% per sheave. And, the number of sheaves involved is a function of the number of lines strung up in the blocks. For example, if six lines are used, there are seven sheaves involved. If we use only four lines, five sheaves are involved. To strike a practical medium, we have to assume a 10% loss in the sheaves.

For the drawworks, a 20% loss was assumed. This figure generally conforms to measured losses, and when we consider actual field conditions, the 20% loss is not out of reason.

To obtain a minimum drawworks input horsepower, we have assumed a total loss from hook to drawworks input of 30%, or an efficiency factor of 70%. Once the hook horsepower has been calculated, this value is divided by 0.70 to arrive at the minimum drawworks input horsepower.

Minimum rated drawworks engine horsepower is obtained by "back-tracking" further through the power system from the drawworks input to the engine rating. The losses in this link of the "power chain" can be argued and disputed, proved and disproved all day long. It is recognized that there is a difference between engine ratings, depending upon a number of key factors.

Since hoisting is truly an intermittent service, an efficiency factor of 85% of rated engine horsepower is frequently used and accepted. This 85% efficiency figure implies a 15% difference between rated engine horsepower and actual delivered shaft horsepower under operating conditions. There has been no attempt here to exactly specify any percentage difference between horsepower delivered at the output shaft and the engine horsepower rating. Our prime interest is to go from the drawworks input to engine rated horsepower.

This step takes us through the power transmission system. It may be through torque converters, a power compound hydraulic coupling, electric drives, or even direct. To be on the conservative side, we have selected a loss of 20% from drawworks input to drawworks rated engine horsepower. The efficiency factor in this step is 80%. This, admittedly, is a conservative figure, but, is in the acceptable range.

So, to get drawworks engine rated horsepower, we divide the drawworks input horsepower by 0.80 (for a 20% loss). Assumed hoisting horsepower losses are illustrated in Fig. 3.

Acknowledgments

The basic idea for these tables was originally developed by co-author J. W. Peret more than six years ago when jet bit drilling was in its infancy in the field. Because of the need for brevity in this analysis, it was necessary to omit the results of investigations completed in the original work which evaluated the suitability of tubing and casing for drill strings. Remaining changes further included a revised basis in the form of a slight reduction in annular velocity along with a simplified manner of presentation. For checking out the idea and contributing to the revised basis for these calculations, the authors are indebted to many in the drilling industry. Special thanks go to R. O. Childers, general drilling superintendent, Atlantic Refining Co., Dallas; Benny M. Ray, field engineer, Chicago Pneumatic Tool Co., Fort Worth, Texas; Thomas Pennington, supervising engineer, Humble Division, Humble Oil & Refining Co., Houston; J. T. Carmichael, chief engineer, Mayhew Machine Co., Dallas; Henry Woods, R. H. Nolley (Houston) and Nelson McClain (Dallas), Hughes Tool Co.; Allen Roberts, section head, Drilling and Development Division, Jersey Production Research Co., Tulsa, Oklahoma; and to the management of Sun Oil Company's Southwest Production Division, Dallas, for permission to publish this study.

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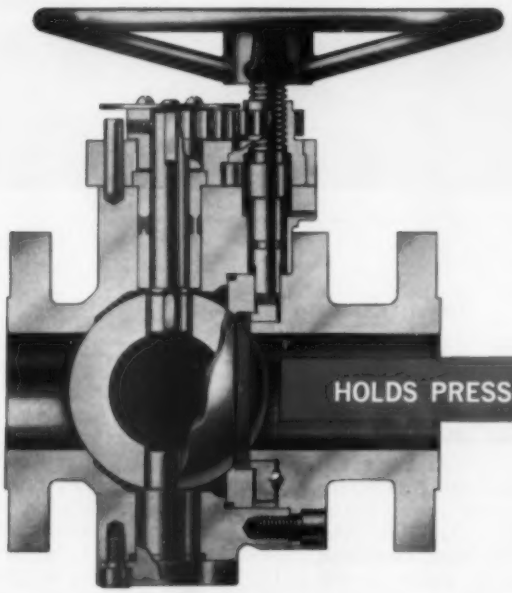

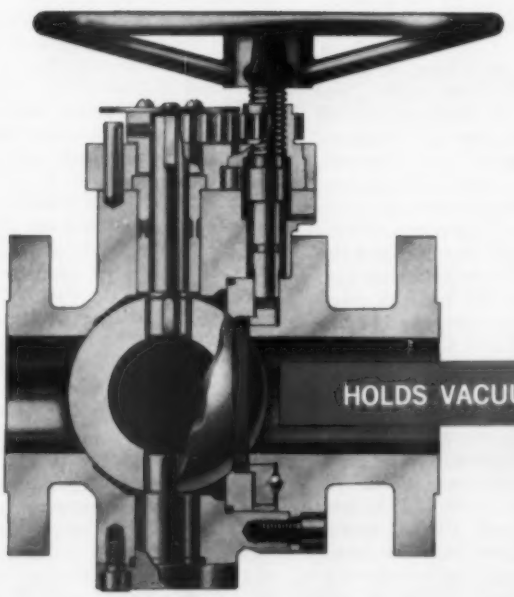

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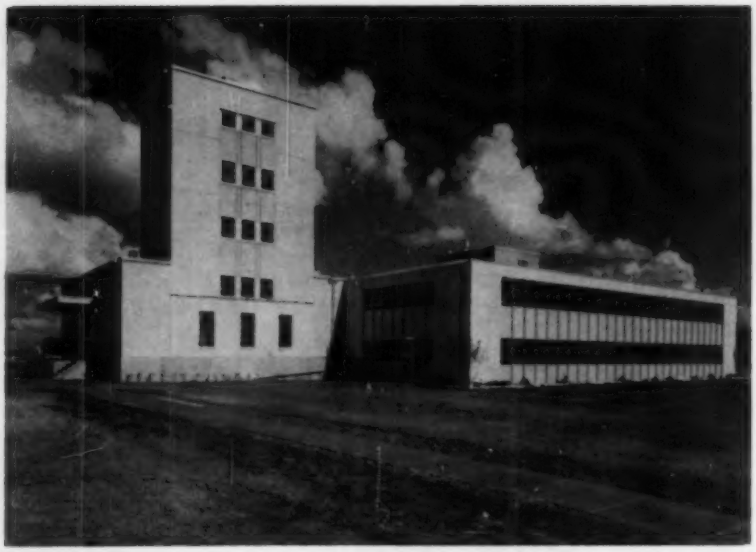

Drilling and development building just completed at Jersey Production Research Company's Tulsa center houses a laboratory devoted exclusively to drilling research and was specially designed to accommodate heavy mechanical engineering equipment. Lab covers 13,000 sq ft of floor space including the tower which houses a specially built drilling machine.

JERSEY RESEARCH ATTACKS DRILLING COSTS

LOWELL A. MURPHY, *Assistant Editor*

Wherever costs are highest, Jersey's research engineers are working to bring them down through practical and basic research

"A MILLION DOLLARS SAVED is a million dollars earned" might well be the motto of the Jersey Production Research Company, Tulsa, Oklahoma. For this company is waging a well-armed war against the high costs of finding and producing oil and is directing its major battles wherever costs loom largest.

The company, an affiliate of Standard Oil Company (New Jersey), was created in May 1958, from the research facilities of The Carter Oil Company, now an operating division of Humble Oil & Refining Company. It conducts the principal production research activities for such Jersey Standard affiliates as Carter Division of Humble Oil & Refining Company, Creole Petroleum Corporation, Imperial Oil Limited, International Petroleum Company Limited, Standard-Vacuum Oil Company, and Esso Standard (Libya), Inc.

Company Organization

Growth of the company and its activities has been impressive. The greatest growth occurred since World War II, from 75 employees in 1945 to over 435 today, of which 200 are professional research scientists. The recent addition of a new drilling and development laboratory with 13,000 sq ft of space brings the total plant area up to 140,000 sq ft.

The research company's board of directors includes representatives from the major affiliates of Jersey Standard. The resulting inter-company cooperation is further increased through a program of employee rotation, or "trade-out," between the research laboratories and the field.

Although operating on a non-profit basis, JPRC is a separate company as one of the Jersey affiliates. The company's general research budget is financed through contracts with the participating affiliates whereby the affiliates contribute in proportion to their own activities in exploration and production. Research work on specific problems from individual companies is billed to the company on a fee basis.

Since JPRC does not operate to earn a profit, it cannot measure its success by the usual yardstick of "dollars earned." Rather, the company gages its effectiveness on the basis of "dollars saved" for its affiliates. And this test of success has proved the company to be a very successful organization.

Recent Research Developments

A look at a number of significant developments in the past few years points up the company's effectiveness. The most impressive accomplishment to date is the company's program of "research-tailoring" of technology to suit the needs of affiliates. Since the first of this year, research engineers have visited affiliate operators in 19 trips outside the U. S. to assist in apply-

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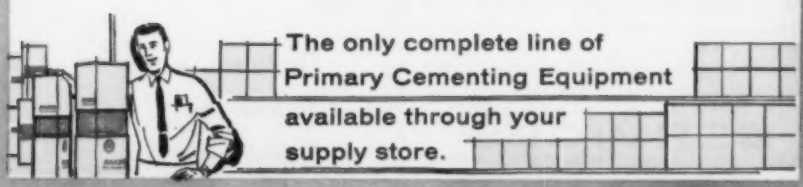

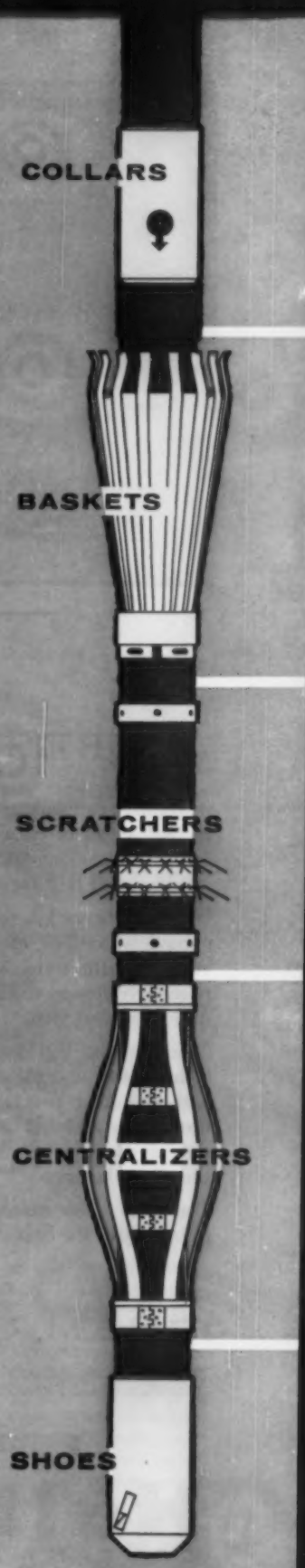

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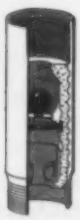

Flexiflow
Fill-Up Collar
Product No. 161 M&F

Circulating Flexiflow
Fill-Up Collar
Product No. 161-D M&F

Cement Float Collar
Product No. 101 M&F

Cement Baffle Collar,
with Hole
Product No. 104 M&F

Cement Baffle Collar,
Solid
Product No. 105 M&F

Triplex
Flapper Valve
Float Collar,
Product No. 134 M&F

Metal Petal Basket,
with Stop Rings
Product No. 343

Plain Hook-Up Nipple
with Metal
Petal Basket
Product No. 330

Avoid welding . . .
lock casing shoes
and collars with
BAKERLOK
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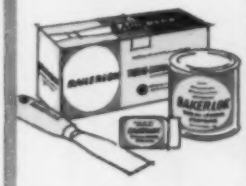
Compound
Product 050



Hinge-Lok Wall
Scratcher, with
4½" long wires
Product No. 900-C

Hinge-Lok Wall
Scratcher, with
2½" long wires
Product No. 900-C

Solid-Ring Wall
Scratcher, with
4½" long wires
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Solid-Ring Wall
Scratcher, with
2½" long wires
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Product Nos.
940-B (Solid)
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Wall Scratcher
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"G-12" Slim Hole
Casing Centralizer
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"HN-15" Solid-Ring
Casing Centralizer
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Casing Centralizer
Product No. 9115

"H-20" Hinge-Lok
Casing Centralizer
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"H-25" Hinge-Lok
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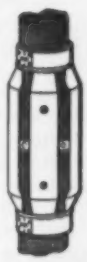

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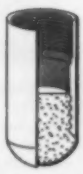
Flexiflow
Fill-Up Shoe
Product No. 160

Cement
Float Shoe
Product No. 100

Cement Wash-Down
Whirler Float Shoe
Product No. 120



Cement
Bull Plug Shoe
Product No. 103

Cement Guide Shoe
Product No. 102

ing tailored technology and to give on-the-spot cost-cutting assistance. As a result, operating affiliates have realized cost reductions which, according to Jersey estimates, pay for the rest of the company's drilling research program.

Other JPRC developments include a rubber-sleeve core barrel used all over the world to get heretofore unattainable cores of unconsolidated formations. A new high-volume, through-tubing flowmeter (see THE PETROLEUM ENGINEER, May 1960, p. B-102) has been developed to delineate flow by zones in high volume production or injection wells.

Field tests are in progress on a new tool described as a wall-anchored drill collar designed to eliminate the need for conventional drill collars for applying weight to the bit. Also, a high power air percussor for use in drilling large diameter holes has been refined and proved.

The company has also developed two new basic research tools: a down-hole recorder and a chisel impact pressure chamber, both used to gain basic information on rock bits.

General Industry Research

The company has formulated its basic drilling research program through analysis of past industry work, which is more extensive than is generally realized. Industry has spent in excess of 25 million dollars, for example, looking for a better way to make hole than conventional rotary drilling. Although at least 34 different investigators have tested some 20 different drilling tools or systems, this work has not resulted in a drilling tool or system that can appreciably cut general drilling costs.

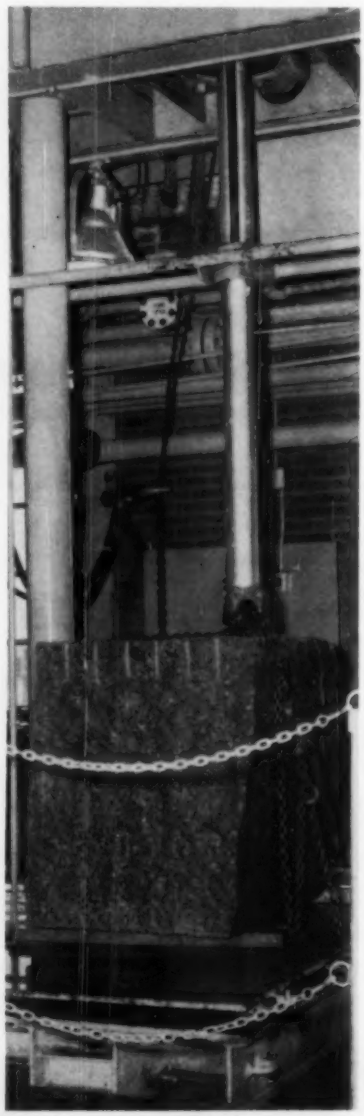
A list of proposed drilling systems that have received the industry's attention is an interesting collection of imaginative ideas. It includes air percussors, downhole rotors (electrodrill and turbodrill), pellet impact drilling, flame drilling, arc drilling, explosive (shaped charge) drilling, shock-wave drilling, high-speed low-torque grinders, abrasive jets, rocket exhaust, chemicals to soften or disintegrate rock, flow of electricity through rock, and magnetic waves. Of these, only the air percussor and the turbodrill have found their way into commercial use, and even their application is quite narrowly limited.

New tools studied by the industry but not yet found in the field include retractable bits, reelable drill pipe, continuous coring tools, and an automatic rig.

Jersey's Philosophy

Analysis of these many efforts to develop new systems reveals, in Jersey's opinion, two basic facts: (1) With only a few exceptions, past developments have been aimed at making equipment based on preconceived and conventional ideas of drilling, rather than on defining the most effective way to break rock and then building the needed system; (2) Industry's problem is not a development problem, but is rather a research problem.

In order to avoid following the generally unsuccessful trend of industry work to date, Jersey believes that research must follow its true function of evolving absolutely new information in two areas: first, theory and principles of rock failure processes, and second, basic physical and engineering data relative to these processes. Therefore, about one-third of the drilling research effort at the Jersey Production Research Center is devoted to fact-finding research seeking the laws and data relative to rock failure.



Drilling stand is part of the full-scale bit performance laboratory in Jersey's new drilling and development building. A tower extends five floors above the stand to permit handling pipe and tools being tested.

CURRENT DRILLING RESEARCH

In line with Jersey's stated philosophy of research, some of the most exciting work now underway at the Tulsa labs is devoted to studying rock failure and new drilling tools. A brief review of some of these studies follows.

Down-Hole Recorder

In order to obtain a better understanding of the conditions under which drill bits operate deep in the earth, JPRC has developed a special research tool to make actual measurements of forces and motions at the bit. This bottom-hole recorder is 6¾ in. in diameter and 15 ft long. It includes an eight-channel tape recorder, 4-in. in diameter, which was recently developed by the missile industry.

Strain gages are used to measure axial load and torque on the bit. Pressure transducers measure pressure inside and outside the drill pipe. Accelerometers measure vertical, lateral, and rotary accelerations. Temperature at the instrument is also recorded.

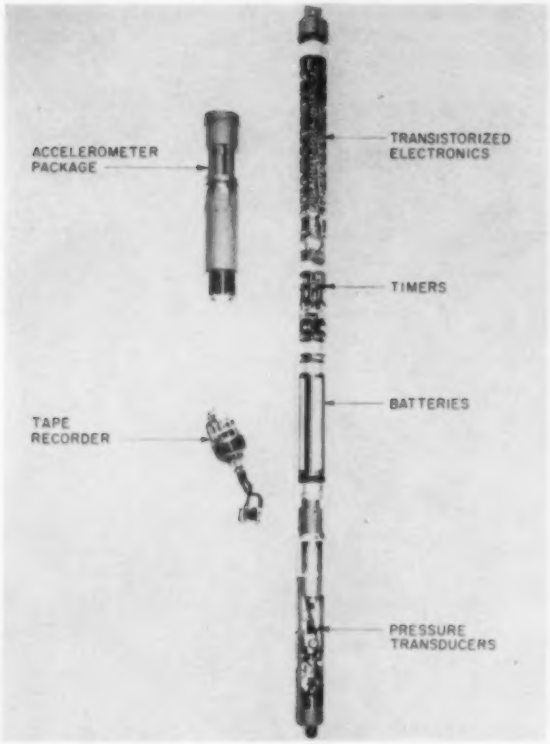
Signals from these sensing elements are amplified in a transistorized electronics package before being recorded on tape. After the instrument is pulled from the hole, information from the tape is fed into a data reduction system which analyzes the information and delivers graphed results for further study.

A series of ten tests at shallow depths has demonstrated that the tool is fieldworthy. Results of these preliminary tests are still being analyzed, however, it is already apparent that bits are subjected to a wider range of loads and frequencies than had previously been considered possible.

Chisel Impact Pressure Chamber

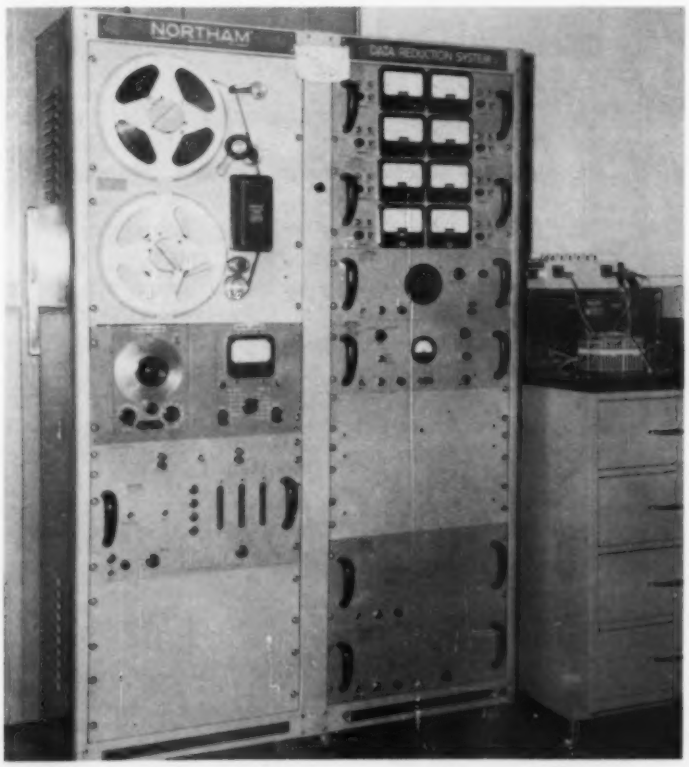
A special high pressure chamber is used to measure the strength of rocks under pressures such as exist deep in the earth. The goal of this project is to study how drill bits penetrate rocks under bottomhole conditions. Since the action of a drill bit is very complicated, a single chisel, stimulating one tooth of a bit, is used in these studies.

The chamber is designed to subject a cylindrical specimen of rock to three independent pressures ranging up to 15,000 psi. Pressures are used to simulate the fluid pressure in the hole, the fluid pressure in the formation, and the weight of the earth above the section being drilled. After these pressures are applied, the chisel is dropped on the

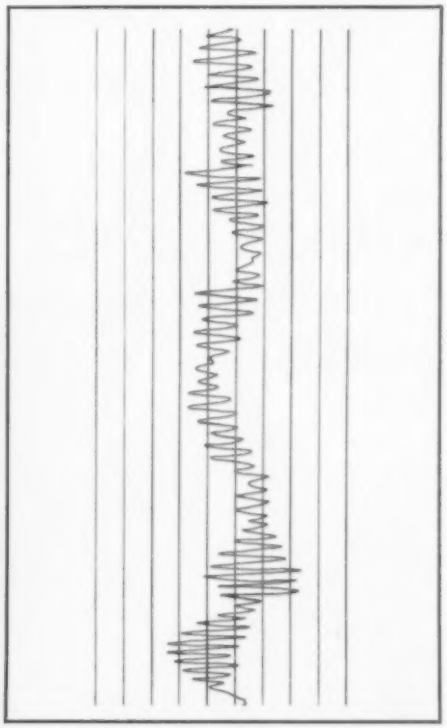


Down-hole drilling recorder measures and records forces and motions at the bit during drilling operations. Sensing elements send information through the transistorized amplifier package to the . . .

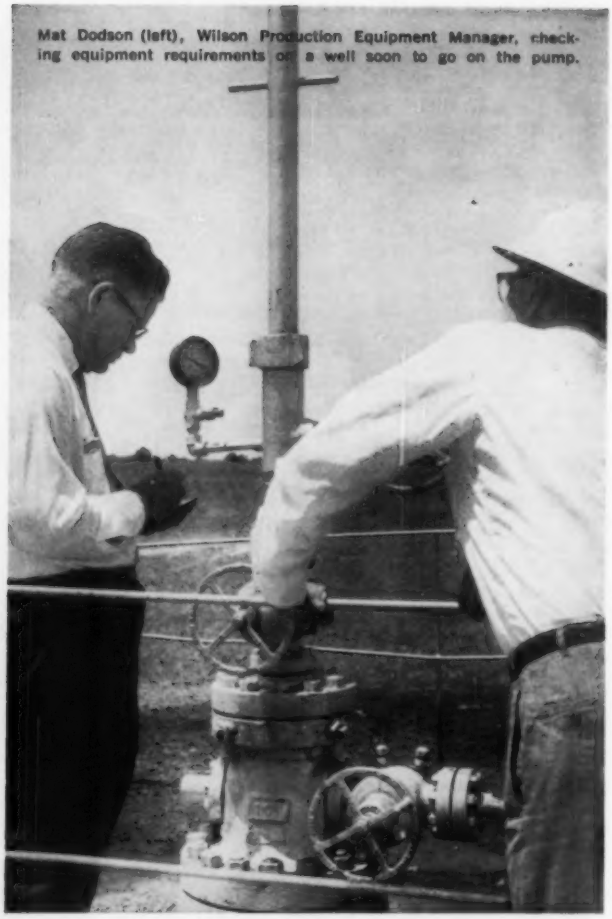
. . . **small tape recorder,** originally developed for the missile industry. Information recorded on the 8-track tape is then fed into this . . .



. . . **data reduction system** which analyzes the 8 variables recorded on the 2-minute tape and then delivers . . .



. . . **strip chart records** of the recordings. This particular record is of lateral motion at the bit and has been filtered electronically to remove extraneous "noise."



Mat Dodson (left), Wilson Production Equipment Manager, checking equipment requirements on a well soon to go on the pump.

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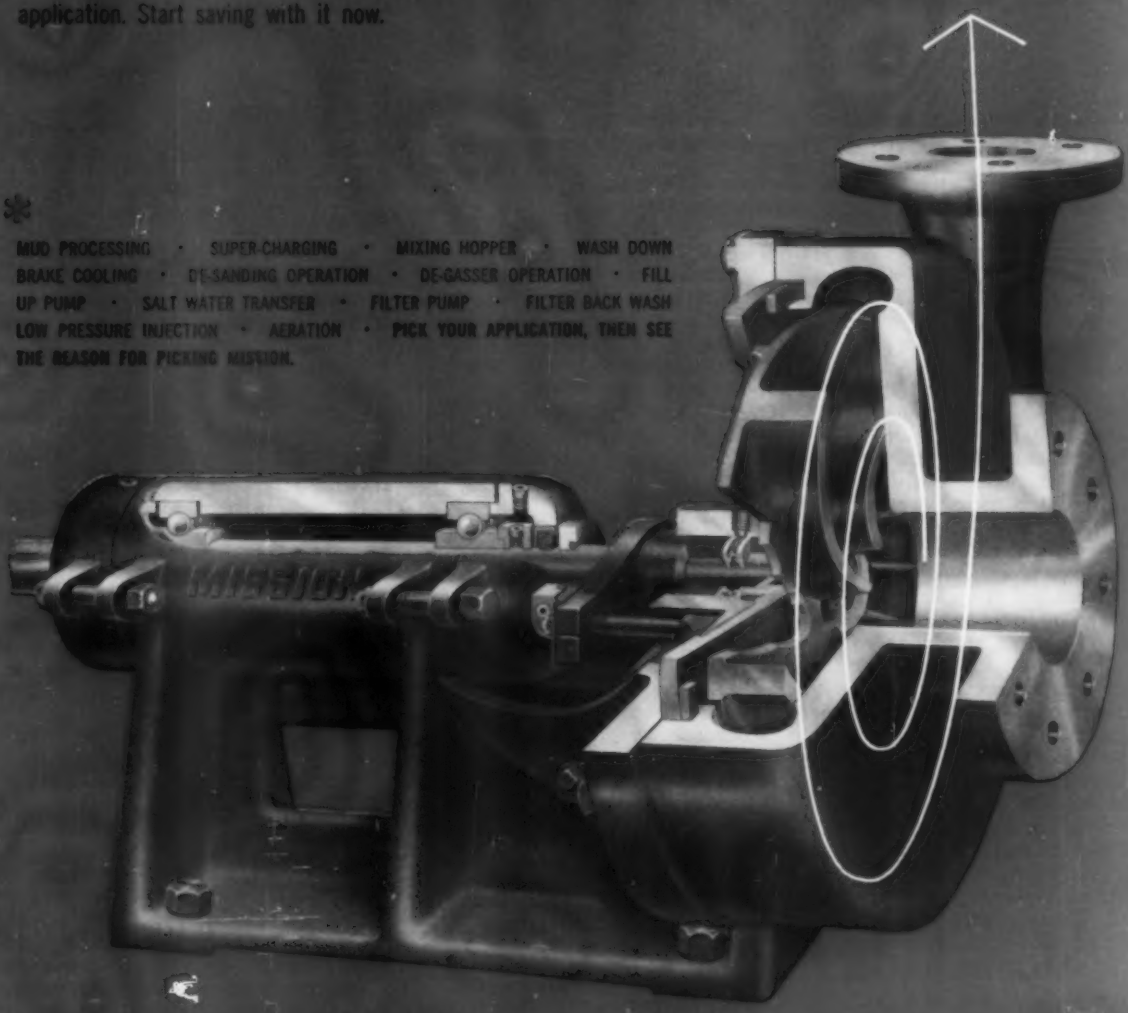

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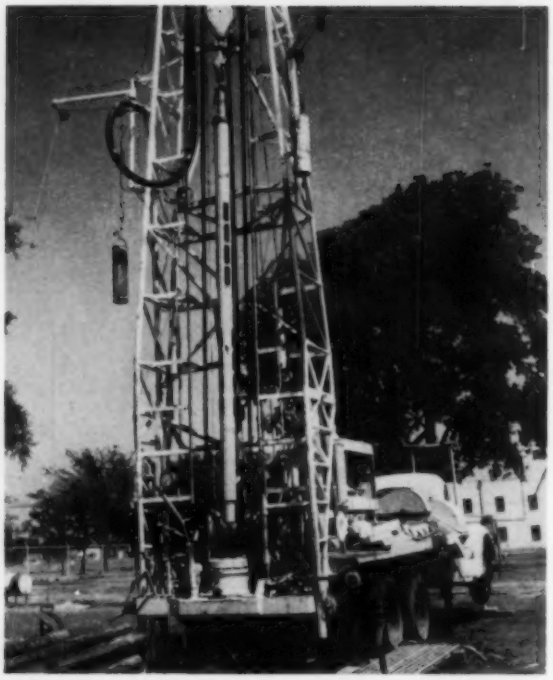
Chisel impact chamber permits researchers to study the action of bit teeth on rock samples submitted to pressures such as exist deep in the earth. High speed movie camera records through a plastic viewing port the action of a chisel on the representative rock sample.



Wall-anchored drill collar hangs in a small rig for tests in JPRC's research center yard. The tool, designed to apply high bit weights without conventional drill collars, has also been successfully field tested.

rock specimen in the pressurized compartment. Resulting loads, displacements, and volume of rock removed are measured and recorded.

This high pressure chamber has four specially designed viewing windows approximately 4 in. in diameter and 4 in. thick. A high speed motion picture camera photographs the action of the chisel at speeds up to 9000 frames per sec. Closed circuit television is also used to watch the test when a permanent record is not required.

For protection of personnel conducting the experiments, the pressure chamber is installed in a special room constructed of concrete blocks and lined with ¼-in. steel plate and 2-in. thick wooden boards.

During the short time that this research apparatus has been in operation, some interesting high speed movies have been obtained which show quite graphically how the strength of rock increases with pressure. An extensive series of experiments is planned to establish the magnitude of this strength increase. These studies will also investigate the importance of absolute pressure, differential pressure, chisel angle, striking velocity, striking energy, and various fluid properties.

Wall-Anchored Drill Collar

The research center has developed a hydraulic wall-anchored drill collar which can be used to apply high bit weight without the use of conventional drill collars. (See article on page B-98.)

The new tool, which weighs only 2200 lb, or about 5 percent as much as equivalent collars, can apply the same weights hydraulically utilizing the pressure drop across the bit.

This tool is representative of Jersey's research philosophy. Conventional drill collars have done their job satisfactorily for many years and have rarely been considered a limiting factor in economical drilling practices. Yet the new hydraulic drill collar, developed primarily to achieve high bit weights at shallow depths, has the potential of saving thousands of dollars on any rig or drilling program.

These savings will result from eliminating expensive drill collars from the standard rig equipment, reducing the total weight of a rig, and streamlining the actual drilling operation by eliminating the necessity of handling the large, heavy drill collars on the rig floor. In addition, use of the new drill collar will extend the effective depth rating of a rig by reducing the hook load imposed while running or pulling the drill string.

Fluid-Entry Analyzer

Of special interest for completion and workover operations is a new fluid-entry analyzer which locates points of entry of water, oil, and gas within a producing well. The device is basically a well-logging tool which uses a radioisotope and gamma-ray detector to determine density of fluids flowing through the well bore.

Used in conjunction with the downhole flowmeter developed by Humble, the combination tool can measure location, direction, amount, and type of fluid entering the well. Gas-oil contacts have been located with the tool in wells while producing and while shut in.

The fluid-entry analyzer and the downhole flowmeter can both be run through 2-in. tubing. Electrical conductors in the wireline logging cable provide control of the downhole tools and transmit signals from them to the surface.

Basic Research Leads the Way

Jersey Production researchers feel that increased emphasis must be placed on systematic drilling research. Fundamental studies will develop principles and engineering data that can hasten major rotary drilling improvements, as well as pave the way for systematic evolution of any new system that may be superior to rotary. Once research has developed adequate basic information, equipment development programs can then be initiated toward preconceived end results, with the knowledge that such programs will have a very high probability of success.

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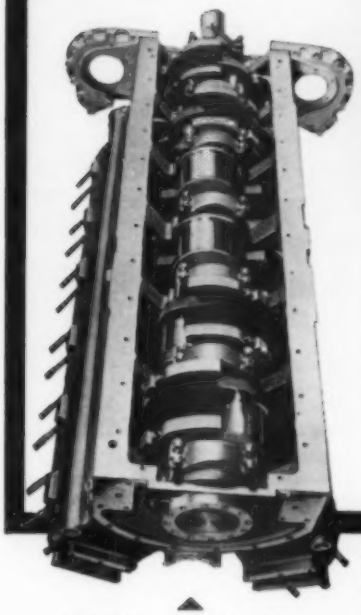
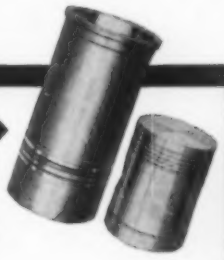
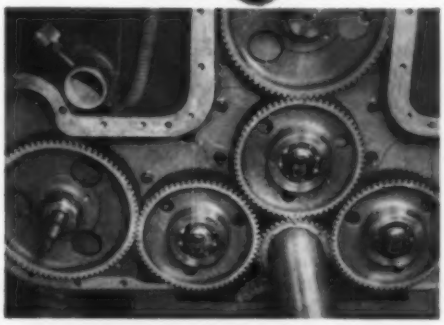


Crankshaft and main bearings in place in a typical Waukesha V-12 oil field engine. Note heavy flanges, thick bearing webs, rugged long-life construction.

Precision-built and balanced rod assemblies, matched with pistons. Pressure oiled, mirror smooth, heavy pins. Replaceable bearing shells.



Removable wet cylinder sleeves of close-grained alloy iron, finished for oil retention and long life. Heavy duty, aluminum alloy, oil-cooled pistons.



Wide-faced helical cut timing gears are flood oiled. Materials selected for long, quiet life and accuracy. Gears and all elements in the power train, from pistons to flywheel, are precision-machined in Waukesha shops under Waukesha Quality Control.

Rifle-drilled, drop-forged, heat-treated crankshafts, precision-ground to exacting Quality Control standards. Note extra large bearing areas. Statically and dynamically balanced.

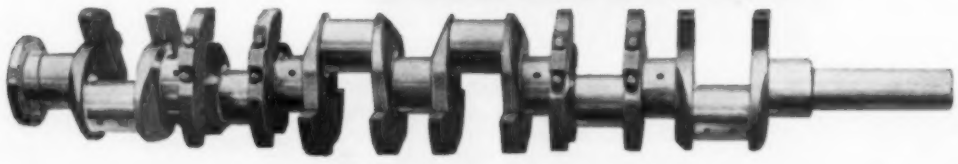


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FIG. 1. **Drilling with air motor** appears identical to drilling with conventional air methods . . . until you see that the rotary table isn't turning. With rotary power generated by the down-hole air motor, the rotary table is merely locked or turned slowly to the right to overcome rotary reaction from the air motor.

AIR MOTOR DRILL

Promises drilling improvements

H. J. MAGNER, *Vice President*
Delta Drilling Company, Pittsburgh, Pennsylvania

Field tests show increased penetration rate and straighter hole with this new drilling tool

THE AIR MOTOR DRILL in recent field tests has shown its potential as a valuable tool in the continuing fight against increasing drilling costs. The new drill promises to be particularly effective in increasing penetration rates, reducing required weight on the bit (due to its high speed), and maintaining straight hole in steeply dipping formations.

The air motor drill is basically simple in design. It consists of two vane-type motors in parallel, driving a common shaft. This shaft turns at approximately 4000 rpm but is geared down to 400 rpm as its normal free speed.

The tool is approximately 8 in. in diam and 10 ft long and is connected to the bottom drill collar of the string. A bit or drive sub at the extreme end of the tool is threaded for a rotary rock bit.

Compressed air flows down the drill pipe and collars through the air motors, driving the shaft to rotate the bottom sub and bit. Air passing through the motor is exhausted through the ports of the bit, but any surplus air can be deflected through a by-pass around the air motors to the bit.

In principle, the tool is similar to an air turbine, but the standard turbine has a greater speed and requires a much greater reduction. The tool which we first used was manufactured by Ingersoll-Rand Company.

Experimental Field Tests

Delta Drilling Company employed the air motor drill on its three initial field tests with the following results.

Comparison with conventional air

a christmas tree is only as strong as its weakest seal

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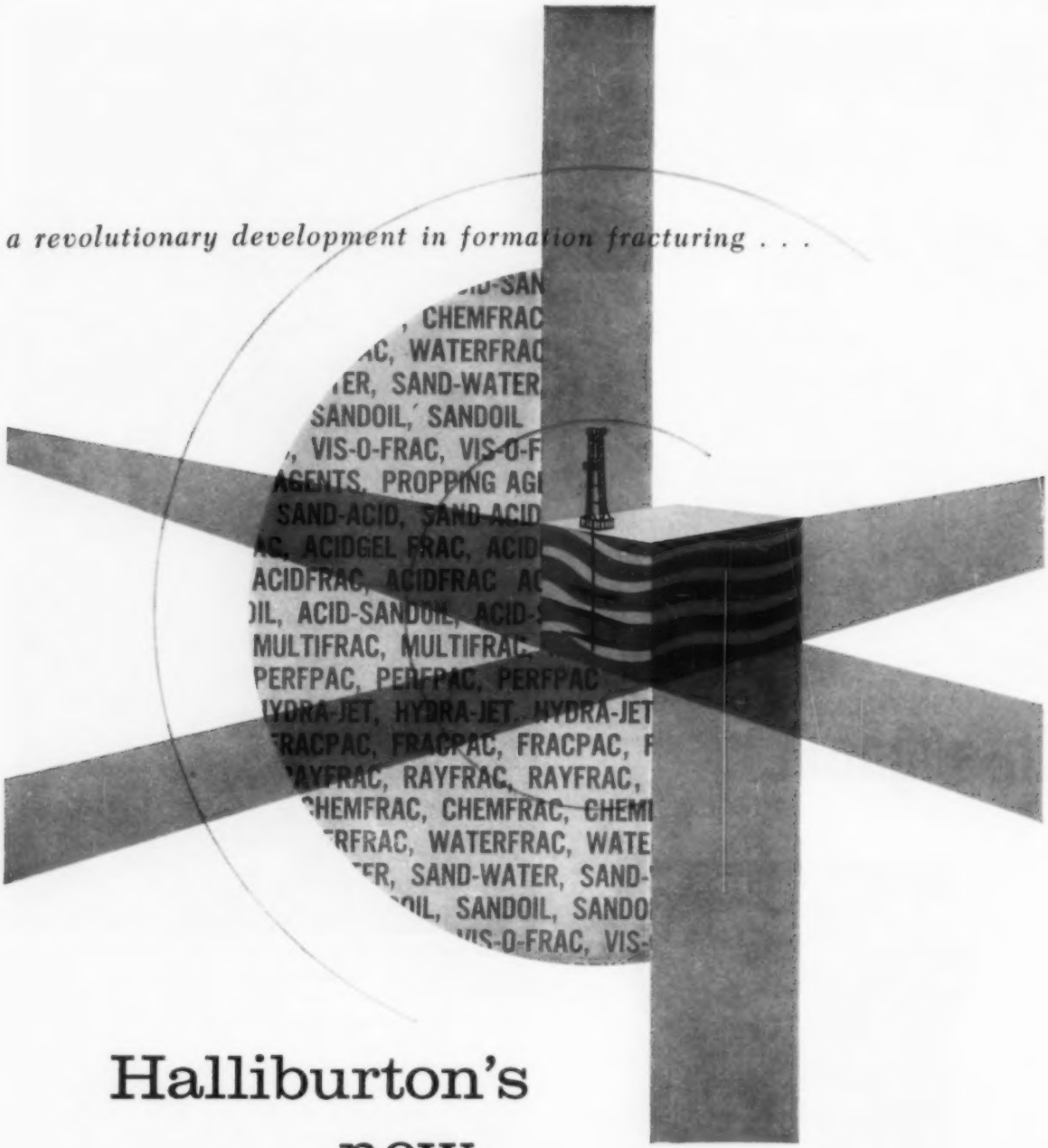

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WHAT IS FRACPLAN?

FRACPLAN is a new Halliburton method to help you design better fracturing programs. Through its use Halliburton can better assist you in selecting: • The proper fracturing fluid and treatment volume • The proper "pad volume" for conditioning fracture surfaces • The type and optimum amount of propping agent for high flow capacity • The proper propping agent-to-fluid ratio for more even distribution within the fracture.

This **FRACPLAN** Method is largely dependent upon specific laboratory evaluations of formation cores and fluids.

HOW WAS FRACPLAN DEVELOPED?

In 1959, Halliburton published a Technical Report describing a method of fracture treatment design. Information gained through the applied use of the theories, ideas and practices presented in this report, coupled with additional research and development by the petroleum industry . . . plus years of experience in formation fracturing have now been combined into this new approach to fracturing – **FRACPLAN!**

HOW IS FRACPLAN BETTER?

The original Halliburton Fracture Design answered a pressing need of the industry by setting up guideposts with which to program treatments.

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methods. It was decided to make the experiment in an 8¾-in. hole at a shallow depth with a tungsten bit to check out the tool's ability to drill in competition with conventional air methods. For comparative purposes, a 1000-ft interval was drilled from 1575 to 2575 ft in Clearfield County, Pennsylvania, for the New York State Natural Gas Corporation.

Four compressors producing approximately 2000 cu ft per min were used. Pressures ranged from 130 to 200 psi, but consistently stayed in the 160-psi range. Bit weights varied from 10,000 to 18,000 lb; beyond this upper limit, the tool had a tendency to stall out. Although it is not necessary to turn the rotary table, we either locked the table or turned it slowly to the right to overcome its natural tendency to back up.

The 1000-ft interval was drilled in 12 hr and 22 min "on bottom," giving a penetration rate of 81 ft per hr, approximately twice the penetration rate normally achieved in the area. Laboratory examination of the tungsten button bit showed a small amount of gage wear but it could have made additional footage. Deviation of the well remained constant in the range of 2½ deg. The tool itself was returned to the laboratory for investigation and was found to be in satisfactory condition.

Shallow drilling with low bit weight. As a result of the success of the initial experiment, it was decided to try the tool on an 11-in. surface hole in Maryland for Snee & Eberly Gas Company. Purpose of the experiment was to determine the possibility of using the air motor drill at shallow surface depths where normal bit weights are impossible.

The same physical equipment was utilized, except that a conventional tooth bit was employed. A section from 48 to 97 ft was drilled. Water encountered in this section caused sticking of the bit and tool for short intervals.

Penetration was difficult to calculate, although rates of approximately 25 to 30 ft per hr were achieved when the operation was trouble-free. Due to hole dampness and tendency of the bit to stick, back-torque on the tool was higher than normal. As a result, make-up connections were broken when the tool was removed from the hole.

We had hoped to test foam drilling techniques with the tool in this hole, but due to the condition of the tool no further experimentation was done. This technique should have eliminated the tendency of the bit to stick and would have allowed the tool a much better set of circumstances in which to operate.

FIG. 4. **Cones show little wear** after being taken from a bit which had drilled 1000 ft of hole in Clearfield County, Pennsylvania. Penetration rate of 81 ft per hr was approximately twice that normally achieved in the area. Weight on the bit varied from 10,000 to 18,000 lb.

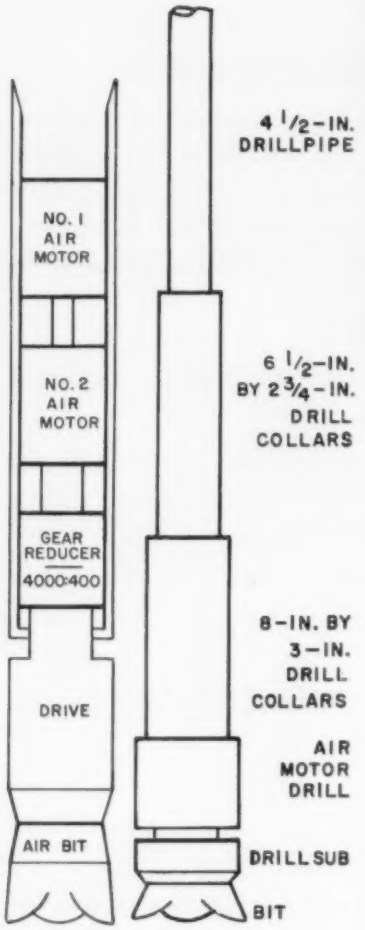
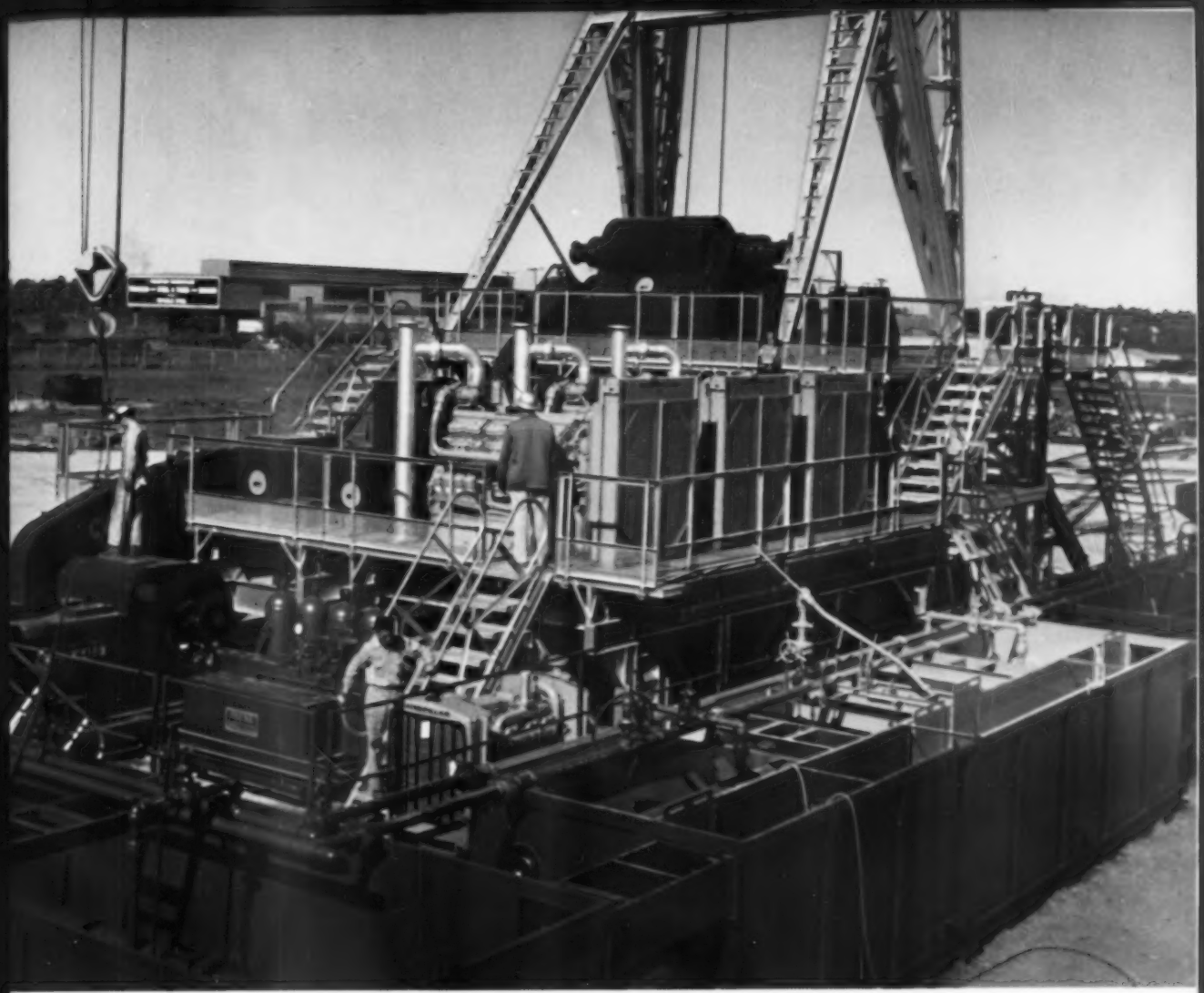


FIG. 2

FIG. 3

FIG. 2. **Air motor drill** is comprised basically of two air motors in parallel driving a drive sub through a 10:1 gear reducer. Normal speed of the air motors is 4000 rpm resulting in a bit speed of 400 rpm.

FIG. 3. **Typical drill string** as used in tests of the air motor drill was made up of 4½-in., 16.60 lb-per-ft, Grade E drill pipe; 360 ft (12 joints) of 6½-in. by 2¾-in. drill collars; 120 ft (4 joints) of 8-in. by 3-in. drill collars; air motor drill; and 8¾-in. tungsten air-type rock bit.



This is a complete rig-up of a National Supply rig before shipment from Houston, Texas.

National Supply's Rig-Up Service pays for itself by eliminating problems at the well site

National's optional rig-up service can prevent many costly problems with rigs destined for domestic or overseas service. National Supply facilities and crews at Torrance, Calif., and Houston, Texas, are available for complete assembly of the rig, test operation, lubrication and adjustment. This service is your assurance that field assembly will be fast and 100% effective. It pays off by preventing delays when downtime can ruin a schedule. Your National Supply representative will be glad to discuss the details of this self-liquidating service with you.

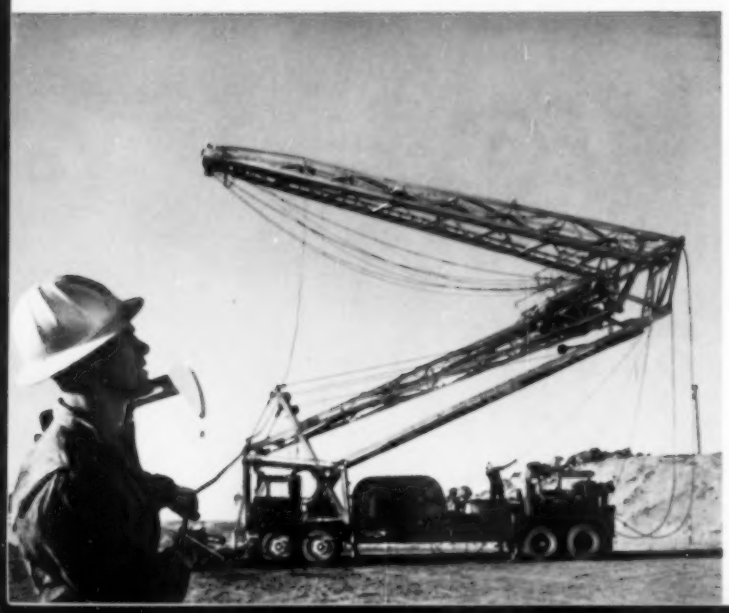
See next pages for information on National Self-Contained Rigs

National's SELF-CONTAINED Drive-In Rigs
set new standards of portability, speed, safety

Balance, modern design, conservative ratings and accessibility of all working parts . . . these are a few of the many reasons why National's *Self-Contained* Drive-in rigs are superior.

Both National Supply self-propelled Drive-in rigs, the Model 200 and Model 300-B, are carefully engineered for every oil country job from rod and tubing servicing to deep workover.

The action picture story on these pages points out only a few of the features of National *Self-Contained* Drive-in rigs. Write for complete information, or call your National Supply representative for details.



1 This National Model 300 Drive-in rig is pulling into location on a remote Colorado drilling site. Roadability and ease of handling of these rigs are due to heavy duty tandem front axles, power steering, and modern Eaton tandem driving axles.

2 Here the folding-type mast is being raised to the vertical position. This mast requires no ground guys, and folding outriggers on the mast superstructure provide stability. Other types of masts are available, depending on customer's preference.

3 The mast is now in vertical position with a minimum of effort or time. Mast clear-heights for the two models are: Model 200—88′5″ and Model 300-B—96′6″. Hydraulic mast erection systems are standard on both Drive-in models.

4 Crew is now ready to start raising tubing. Note the compactness of the National rig. Model 300-B dimensions are as follows: overall length, 49′; width, 8′; wheelbase, 25′. Model 200 dimensions are: overall length, 45′; width, 8′; wheelbase, 19′.

5 This is a side view of the Drive-in rig in place. Hoist controls are extremely convenient and are normally mounted on the right hand mast outrigger. Ample air compressor and air reservoir capacity for rig and vehicular operation is provided. A hydraulic system for tubing tongs is available.

6 Work over and tie-in with tank battery are completed. Both the Model 200 and 300-B are equipped with sand reels of large spooling capacity. Brake rims and blocks on the main and sand reel drums are interchangeable. Although unit is light weight for maximum portability, solid construction assures complete safety in all operations.

Steel

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See next page for information on new T-45 rig

Total flexibility of power and portability are features of this 550-horsepower T-45 drilling rig recently shipped to Libya. The rig is transported on six trailers and is the largest and most powerful ever designed for fast transportation in desert areas by the National Supply Company. All trailer wheels are equipped with extra size desert-type tires. As shown above, the rig was rigged-up and test operated at National Supply's Houston, Texas, plant prior to shipment.

New National T-45 Rig is compact, versatile

. . . specially suited for trailer mounting

National Supply's new T-45 rig features compactness, light weight and simplicity of construction. The rig is "tailor made" for fast, efficient drilling operations, having automatic, safe and precise air controls for hoisting, braking and rotating functions.

It is designed for use with torque converter equipped engines. The T-45 rig may be powered with one or more engines developing a total of 450 to 600 horsepower. Although the T-45 is offered as a conventional skid mounted drawworks, it is especially suited to trailer mounting. Here are a few of the T-45 features:

AIR OPERATION gives precise, synchronized power. Dependable pneumatic equipment gives accurate control of the compressed air power, fully protects the rig for safe operation.

STREAMLINED CONTROL PANEL simplifies operation, makes it safer, more precise. Easy-to-reach levers make it easy for operator to control each phase of the drilling cycle.

WATER JACKETED BRAKE RIMS give efficient, continuous cooling, and the large main drum affords longer wire line life.

TORQUE-CONVERTER EQUIPPED ENGINES permit faster round trips, better pump performance and improved rotary operation.

Write for complete details on new T-45 rigs in Bulletin 504, or call your nearby National Supply representative.

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Owner — Austral Oil Company Incorporated, Houston, Texas

Job #1 — 7⅝" O.D. casing string set at 10,277' in 10⅝" hole, cemented with 500 bags UNAFLO cement plus 6% gel (slurry wt. 14.7 lbs/gal.) followed by 200 bags UNAFLO cement neat, (16.3 lbs/gal.). Drilling mud wt. 13.4 lbs/gal. Schlumberger temp. log 181° F. Est. static BHT 213° F.

Job #2 — 5½" O.D. liner, 2,146' long, bottomed at 12,000' in 6¾" hole cemented with 320 bags neat UNAFLO cement. Drilling mud wt. at cementing 16.4 lbs/gal. Schlumberger temp. log 255° F. at 12,160'. Est. static BHT 265° F.

Job #3 — 5½" O.D. full casing string tied to top of 5½" O.D. liner, using liner to casing coupling with 100 bags neat UNAFLO cement.

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Drilling in steeply-dipping formations. The third test had a two-fold purpose. We primarily desired to see what effect the air motor drill would have in steeply-dipping formations, and we also desired to see how much hole could be made on one run with the tool.

We again used the same surface equipment, using an 8¾-in. tungsten bit, and drilled an interval from 4770 to 6525 ft. Bit weight approximated 14,000 lb and the same air pressure existed.

The 1755-ft interval was drilled in 16 hours and 2 minutes, amounting to 108 ft per hr. Hole deviation went from ¾ deg at 4891 ft, 1¼ deg at 5500 ft, 2¼ deg at 5825 ft, and 2¾ deg at 6189 ft. This seems like a steady increase, but the area is noted for deviation difficulties. As a matter of fact, deviation was at 7 deg at 6805 ft after we resumed conventional air drilling methods.

The rock bit was returned to the manufacturer for examination and found to be in excellent shape. Most of the bearings were still to original specifications. However, when the air motor drill was returned to the laboratory and inspected, it was found that dust had worked into the bearings and some wear was noted.

Summary of Test Results

Although the tests are not thoroughly conclusive in all respects, results indicate that the air motor drill has potential to increase drilling rate appreciably. It definitely should be a deviation control tool since it employs the basic principles of hole control: light bit weights and high rotating speeds. The tool should also be applicable to shallow areas where desired bit weights are difficult to achieve. No doubt many problems will be encountered in perfecting the tool, but these should be overcome through experimentation and experience.

What Does It Cost?

The air motor drill should not be too expensive a piece of equipment to manufacture. If its repair and maintenance costs are reasonable, it should not be economically prohibitive for general use.

In these tests, we found that a break-even point was reached on the 1000-ft interval (first test). Time saved by higher penetration rates was offset by bit cost increases and time required to pull the tool from the hole.

However, on the 1755-ft interval (third test), penetration rates showed a greater saving of time and the bit life was extended over the first test (even though still approximately one-half that of conventional air drilling), and a greater interval was drilled without making a trip. We calculated a saving of 50 cents per ft in this section of the hole.

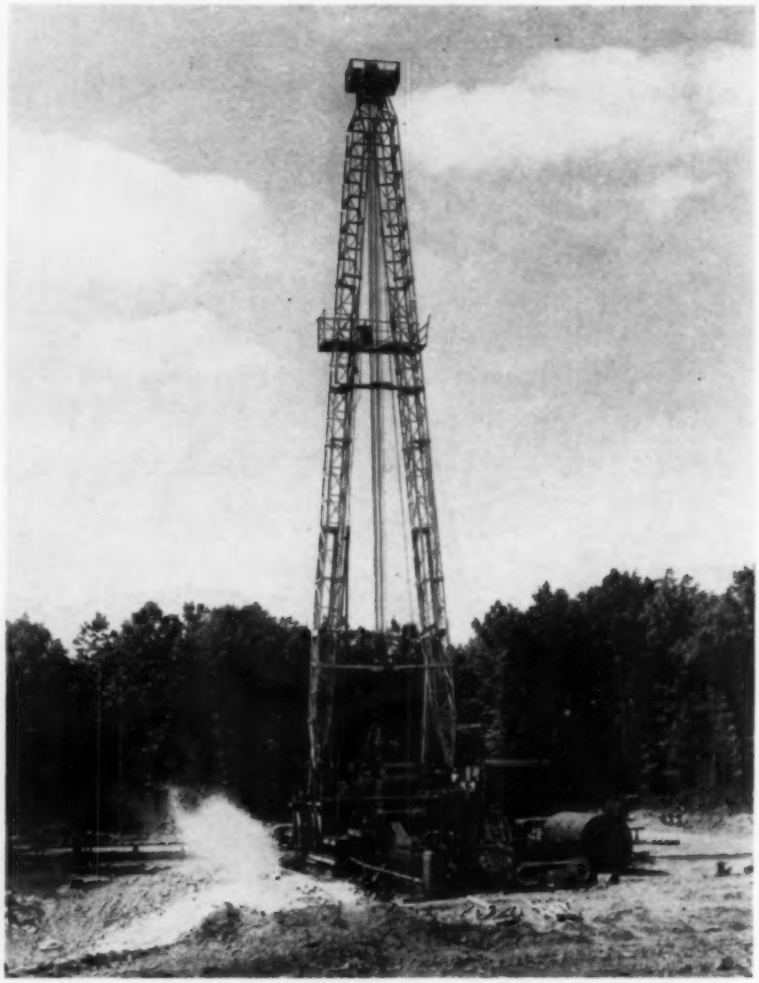

FIG. 5. **Foam drilling holds promise** of extending use of air motor drill to holes in which water is encountered. In one test of the air motor with air, water in the hole caused the bit and tool to stick for short intervals. Resulting back-torque loosened make-up connections.

Conclusions

We do not think that this tool is a panacea. Actually, since the tests have been run, we have further improved air drilling techniques, reducing the relative effectiveness of the air motor drill. For example, penetration rates of 60 ft per hr have been recorded of late, with one or two bits used over a 6000-ft interval.

If consideration is given to the cost of the tool, probable increased bit expense, and extra rig time for trips, then this technique will find conventional air methods a rough competitor. However, the basic principle of utilizing horsepower or air power at the bottom of the hole seems to be of great importance.

Satisfactory performance with light weights on the bit would require fewer expensive drill collars. Deviation control is a major factor in air drilling since a reduction in weights under conventional methods can drastically reduce the potential achievements. It would appear, therefore, that the air motor drill will find many places for its economic use, yet it still will not be employed in other areas. Like all of the other downhole drills, its success will be governed by the efficiency of the tool, the bits which it rotates, and the hole conditions encountered. ★ ★ ★

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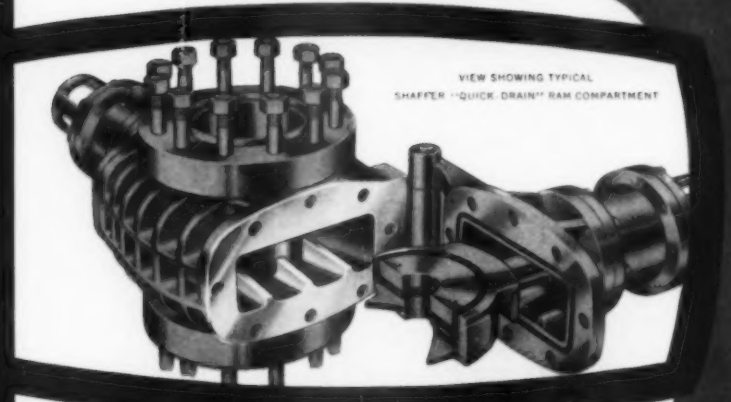

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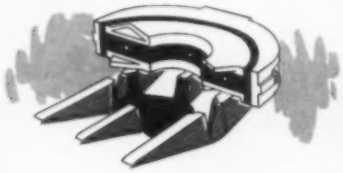
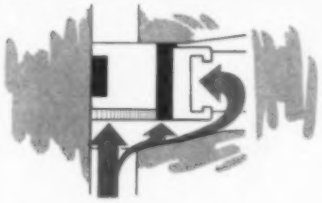
▼ ***In Shaffer Blowout Preventers the rams travel on guide ribs high above the compartment bottoms. These ribs are narrow, reducing to a minimum any chance of mud or sand gathering on the sliding surfaces. Furthermore, the little that might collect on these narrow ribs is quickly and easily wiped off by the rams as they open or close!***



▼ ***Then note the compartment bottoms. These are steeply-sloped downward toward the well so that any sand and cuttings that might normally settle in the compartment area are quickly drained back into the well.***

▼ ***The more-than-ample clearance between the bottom of the rams and the compartment bottoms also provides another important advantage ...should pressure build up in the well, this pressure can quickly and freely flow to the back of each ram to balance the pressure against the front face for easy closing action.***



Therefore the unique "Quick-Drain" design of Shaffer Preventers:

(1) prevents detrimental accumulation of mud, sand and cuttings within the ram compartments.

(2) assures pressure balance between the front and back of each ram as the rams are closed.

Result ***—whenever pressure emergencies threaten, neither mud, sand nor well pressure interferes with fast ram closure when you are using Shaffer equipment!***

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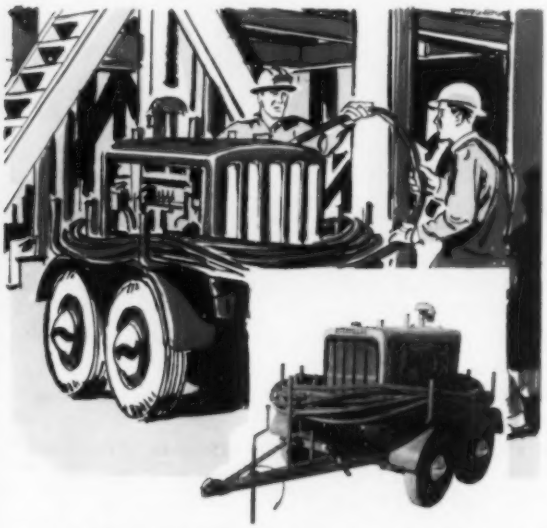

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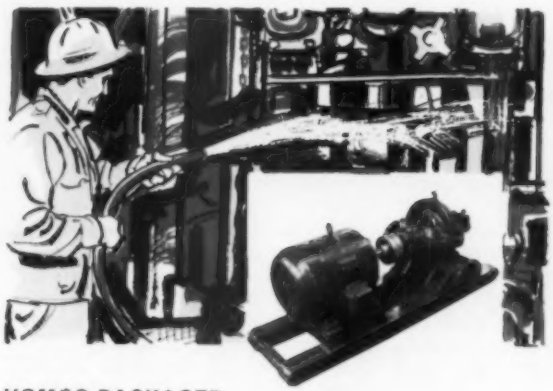

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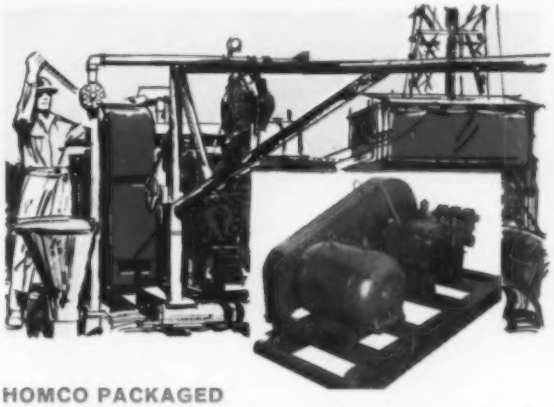

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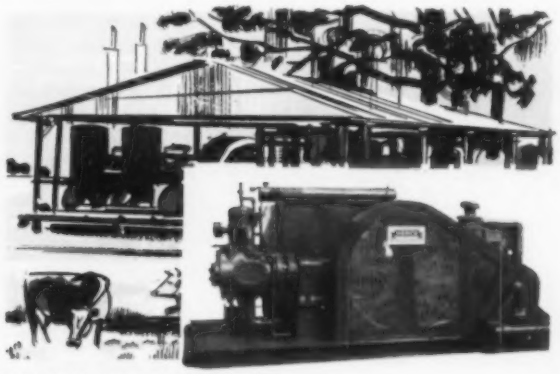

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Basic guides for the . . .

selection of economic hole size for slimhole drilling

WESLEY W. MOORE, *Drilling Analyst,*
The British-American Oil Producing Co., Dallas, Texas.

An engineering analysis of recent slimholes point the way to achieving economies in drilling small-diameter holes. Some current thinking on the subject and a new approach to selecting hole sizes are given

IT NOW APPEARS FEASIBLE to apply some basic guides in selecting economical hole sizes for drilling so-called "slimholes" to a given depth on the basis of considerable experience and the application of pertinent engineering factors. An important guide in making such a selection has been devised based on the slenderness ratio of the well. This ratio is defined as the depth of the hole (in feet) divided by the hole diameter (in inches) squared. In reaching this conclusion, it is presumed that the drilling rig and drill string are properly tailored for the hole size and that drilling bits used are of current rock bit design.

The term "slimhole" as used to describe actual drilling operations has been defined as a hole too small to receive 5½-in. casing. In well completion practices, "slimhole" refers to the use of 4½-in. casing or smaller. The use of small casing may or may not be related to a small hole. Therefore, this analysis is limited only to slimhole drilling as defined above.

Slimhole drilling practices of today are the outgrowth of a well-defined trend extending over the past 25 years toward smaller holes and smaller casing. During this period, the application of these practices and the purposes behind them have become reasonably well known. And, pending some major breakthrough in rock bit design, a large majority of the small diameter holes drilled will be limited for economic reasons to relatively shallow depths and/or soft formations. Except for these easily drilled wells, it is not possible on a large scale to reduce hole-making costs significantly by reducing bit sizes below 7⅞-in. when used in combination with 4½-in. drill pipe.

Maximum benefits to be derived by drilling small holes will accrue only if a large number of wells of like depth and character are to be drilled consecutively in a concentrated area. Such a program not only permits selecting a rig to suit the exact requirements, but also permits programming operations connected with the project on a better time schedule. Maximum benefits to be derived through slimhole completions may be expected in cases where other elements of well costs are low and where small daily rates of total fluid recovery either are acceptable or are imposed by proration.

In earlier evaluations of slimhole drilling, it was presumed that drilling costs might be reduced somewhat in proportion to the amount of material excavated. This postulation has been disproved by experiences to date.

Rock Bit Design a Problem

The cost of making hole is influenced to a very large extent by the rate of penetration. And, the rate of penetration similarly is dependent in a large measure on bit loading, expressed in pounds per inch of bit diameter. Cone-type roller bearing rock bits are used almost universally today in oil and gas well drilling operations. It has not yet been possible on a commercial basis to make a small rock bit as rugged in proportion to its diameter as in the case of larger bits.

The stamina of a bit depends upon the ruggedness of its individual cone assemblies. The diameter of the cone is approximately proportional to the diameter of the bit. It is the cross-sectional area of the cone near its base, however that limits the size and load capacity of the bearing. This indirect relationship of bearing space to the bit area accounts for the fact that permissible bit loading is very nearly proportional to the cross-sectional **area of the hole.** On the other hand, the required bit loading for equal rates of penetration is proportional to the **diameter of the hole.**

As an example, one manufacturer recommends a maximum loading of 15,000 lb for a 6⅛-in. three-cone bit weighing 28 lb. Bit loading in this case is approximately 2450 lb per in. of bit diameter. But, for its 12¼-in. three-

See chart on Page B-63

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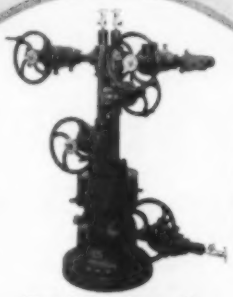
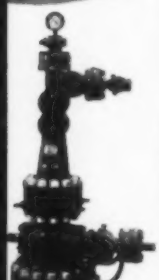
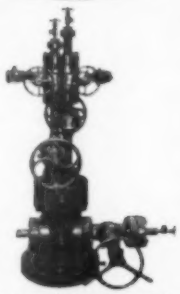


Threaded dual tree with Crescent Flange Bottom

Triple Tri-Flange Tree



Single Unitree



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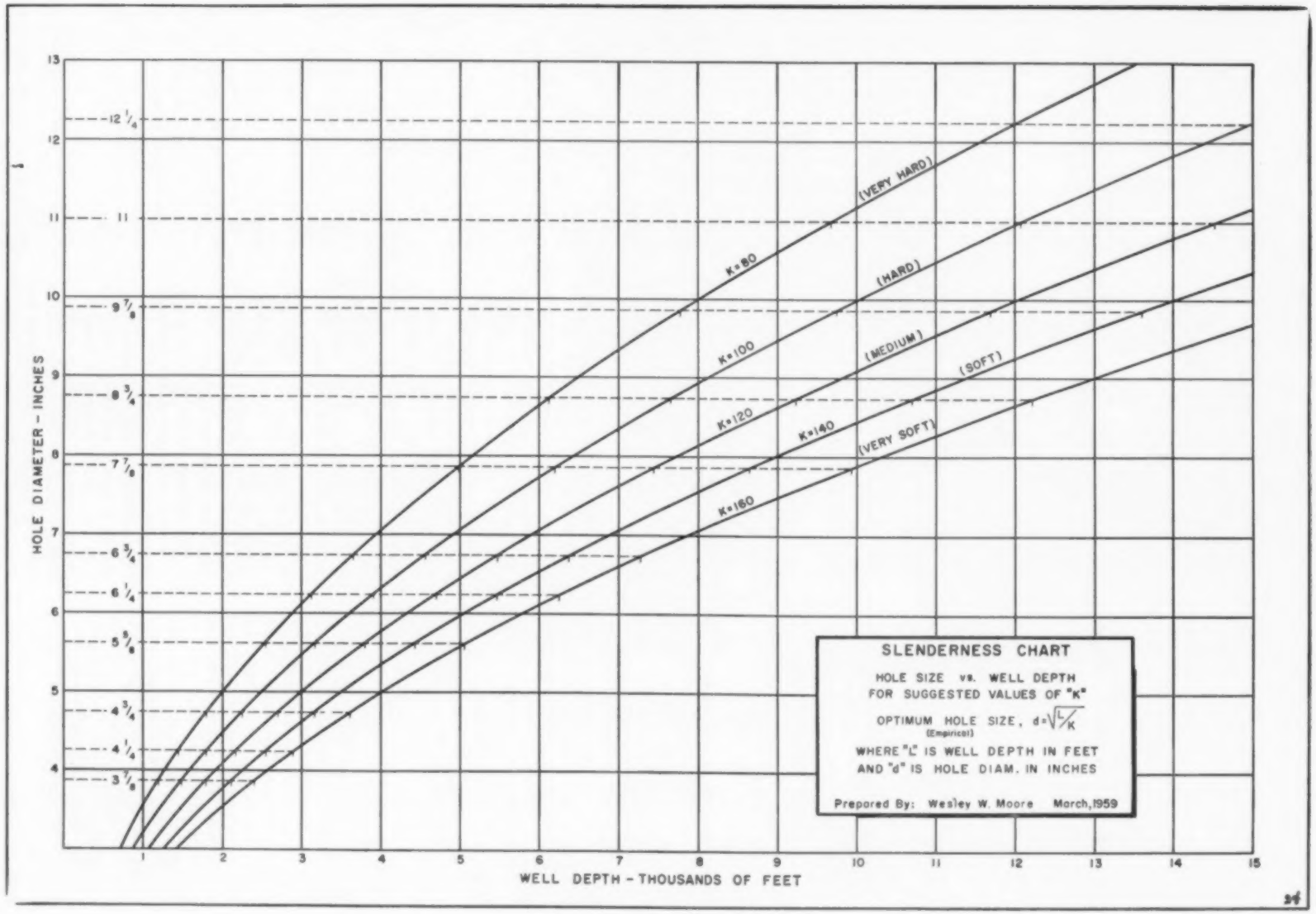

Guide chart for the selection of economical hole sizes in slimhole drilling when formation hardness and depth are known.

cone bit, weighing 185 lb, the same manufacturer recommends a maximum loading of 60,000 lb or approximately 4900 lb per in. of bit diameter. It can be noted in this case that the larger bit (which is twice the diameter of the smaller bit) is more rugged, being more than six times as heavy as the smaller bit and is recommended for four times as much loading.

Needed: A Better Small Rock Bit

Perhaps one of the most important equipment needs for greater economic application of slimhole drilling is a radically improved drilling bit of small diameter. Diamond bits have demonstrated their ability to drill small holes under good hydraulic conditions and in dense formations. But, they have not answered the need for a universal type bit in all drilling conditions including sticky shales.

When using small rock bits of current designs, the lower rates of penetration and the additional time required to make frequent trips for bit changes after reaching a considerable depth are likely to dissipate any savings which may have resulted from the use of a smaller and less expensive rig.

Drill Collar Improvements

Not only is there a need for a better tool on bottom as the hole gets deeper or as the formations become harder, but also there is a need for heavier and more rigid drill collar assemblies. Rigidity of the drill collar assembly can best be obtained by increasing the outside diameter of the collars. Small hole sizes limit the full realization of this possibility using conventional collars.

One Note on Mud Pumps

When dealing with the smaller size drill strings and smaller size holes, the pressure drops per 1000 ft of depth usually exceeds that normally experienced when drilling a conventional size hole with 4½-in. drill pipe. And, since it has been universally recognized that adequate hydraulics are essential for good penetration and bit life, it is essential in successful slimhole operations that adequate hydraulics be provided. However, it is not always possible to accomplish this, primarily due to high-pressure, relatively low mud volume requirements. This puts the finger on mud pumps for slimhole drilling. Therefore, in addition to the need for an improved drilling bit in smaller sizes, perhaps the second most important need for this type of operation is a small-volume, high-pressure slush pump properly designed for slimhole drilling.

Drill Pipe Considerations

To provide the most favorable conditions for good hydraulics in slimhole drilling, it is desirable to use drill pipe having an inside diameter equal approximately to one-half the diameter of the well bore. This relationship can be maintained in all but very small holes without sacrificing clearance necessary for washing over a parted drill string.

Very satisfactory hydraulics are provided by the use of 2⅞-in. OD drill tubing when drilling a 4¾-in. hole. This combination of drill string and hole size, however, does not permit conventional wash-over fishing operations. Therefore, the operator or contractor using this combination must take a calculated risk of occasionally losing a hole and part of the drill string.

In drilling a group of shallow wells, assumption of this risk can be justified entirely. But, it cannot be justified as readily when the risk involves a deep well which at the time of the fishing job, may already have incurred a substantial expenditure.

Rig Cost and Weight

Two of the factors favoring slimhole drilling are the cost and weight of the required drilling rigs. Lower amortization rates and lower transportation and rig-up expenses which result from the use of a slimhole rig will reduce considerably the rig operating expense. In shallow wells, this often is sufficient to more than offset the lower rate of penetration to be expected in drilling small holes.

Slenderness Ratio: A Hole Size Yardstick

It can be concluded from the foregoing discussion that soft formations and shallow depths favor drilling small diameter holes, whereas, harder formations and greater depths favor drilling larger holes. In deeper drilling, hole size sometimes is limited economically by the size and cost of long strings of surface casing or by the size and cost of intermediate casing strings.

It is not always possible in really deep wells to realize the potential benefits of larger bits and correspondingly larger drill strings. Except for these limitations, there appears to be a reasonably definite relationship between well depth and hole size to yield minimum hole-making costs when drilling formations of known hardness.

This relationship can be expressed as a "slenderness ratio," or well depth per unit of cross-sectional area of the hole. For convenience, this slenderness ratio may be expressed in terms of hole depth (in ft) divided by the hole diameter (in inches) squared. This ratio shall be referred to as "K." The proper numerical value for "K" is influenced by the drillability of the formation.

The suggested formula is empirical, intended only to indicate a general trend or "guide" in selecting hole sizes at given depths where experience has indicated improved economies in hole-making costs can be achieved. It is not suggested that these criteria will apply to every slimhole well. But, experience from a wide range of such wells indicates that these expressions will apply to a majority of such wells drilled in areas where conditions are known.

A Chart Guide for Optimum Hole Size Selection

Fig. 1 suggests the optimum hole sizes to be drilled with rock bits of current design to various depths in formations of known hardness. This chart is based on the empirical equation:

$$K = \frac{L}{d^2}$$

and,

$$d = \sqrt{\frac{L}{K}}$$

where,

d = Hole diameter, in.

L = Total depth, ft.

K = Slenderness ratio.

This chart refers only to the hole-making costs and presumes there are no limitations resulting from either the size of the surface casing or the intermediate casing. It presumes also that the drill pipe used in combination with each of the bit sizes shown on the chart will have an inside diameter equal to approximately one-half the hole diameter, or at least sufficiently large to provide good mud hydraulics.

It will be noted on Fig. 1 that curves have been drawn representing five different degrees of formation hardness. It is the author's belief that the Pennsylvania beds of the Mid-Continent area might reasonably be considered of medium hardness, whereas the pre-Pennsylvanian rocks would be considered either hard or very hard. It is believed also that the post-Pennsylvanian rocks would be considered either soft or very soft.

Adjustment of "K" Values

While the "K" values for various formation hardness given in Fig. 1 are based on recent-past slimhole drilled wells, the values assigned to "K" will become subject to revision as more information is obtained from future slimholes, or as equipment and techniques improve.

Acknowledgment

The author and *The Petroleum Engineer* are grateful to the management of The British-American Oil Producing Company for permission to publish this article. ★ ★ ★

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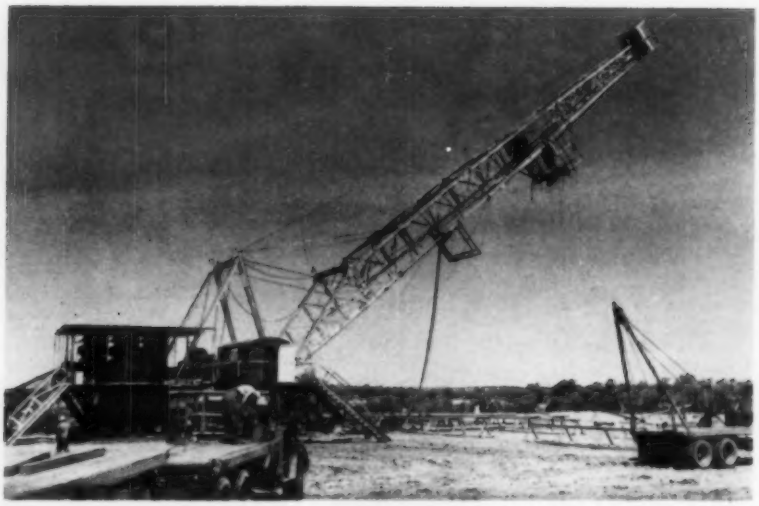


Speed in rigging-up can be attained by unitizing equipment for easier handling, using layout diagram for assembling equipment in same way after each move.

HOW TO CUT RIG MOVING COSTS

Since moving expense can total 20% of footage costs, operators focus attention on unitizing standard drilling equipment and using uniform rig assembly methods on each move for fast rig-ups

MARVIN T. PARKER

RIG-MOVING TIME in some areas may amount to as much as 20% of the total drilling cost, thus the design of equipment for efficient moving is essential.

Design engineers have unitized equipment, designed rotary rigs to assemble in the same way on each move, and standardized equipment design to facilitate fast installation on any rotary rig.

Emphasis on good design for moving rotary rigs will be stressed much more in the future than it has been in the past. Manufacturers, owners, and movers of rotary drilling equipment must all work together to insure the best design for economical moving. Rotary rigs of the future should be designed to be moved and assembled in a few hours.

Designing Rigs for Moving

The modern rotary drilling rig is a massive, intricate machine, and at first sight the smooth operation of this giant is amazing. But it is much less impressive than the time required to disassemble, move, and re-assemble it.

Design of a rotary drilling rig would be easier and possibly much more economical if the unit did not have to be moved. Rotary rigs quite often move every week, however, although they occasionally remain on one location over two years.

Cost per foot of hole when moving often will be higher than on extended operations, and moving expense can amount to 20% of total footage cost in some areas. Operators of rotary rigs have been compelled to watch moving expense more in the past few years than ever before, due to economic conditions.

Standardization. About two decades ago, there were almost as many different rig-up designs and moving techniques as there were supervisors. During the past few years, the trend has been to standardize rig-up designs so that rigs can be moved and assembled quickly with minimum cost. Influence of the design engineer has now followed the rotary rig into the field, where it will be actually used and moved.

Requirements for Moving

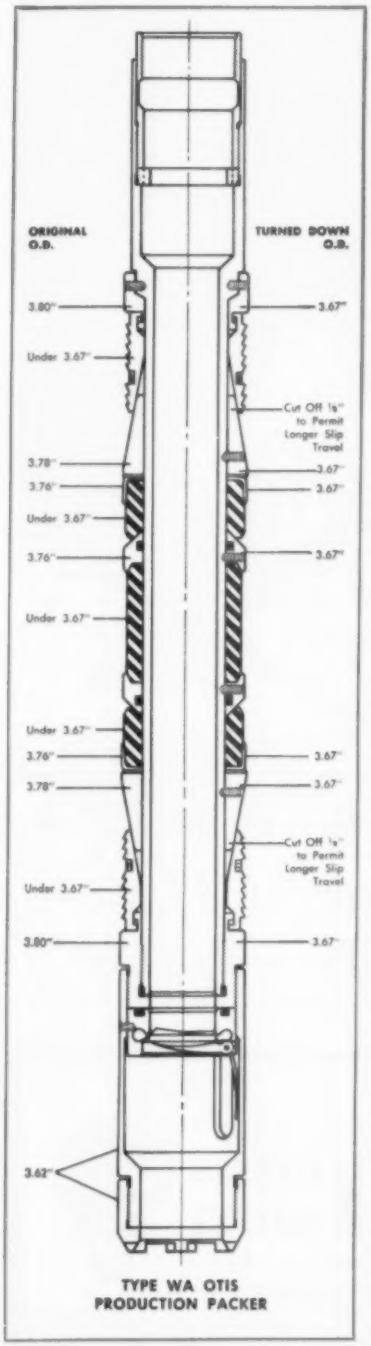
Smaller trailer-mounted drilling rigs weigh a few hundred thousand pounds and the larger land rigs weigh in excess of 1,000,000 lb. This gives the design engineer a great quantity of equipment to work with in designing for less weight and faster moving.

Larger land jackknife drilling rigs will be discussed primarily and references will be made to other types.

Basic necessities of any rig move are good truck personnel, good trucks, a planned schedule for each major piece of equipment and equipment designed for rapid assembly.

OTIS PRODUCTION NEWS

Volume I, Number 3 **Otis Engineering Corporation • Dallas** *Production Equipment and Services*



TYPE WA OTIS PRODUCTION PACKER

Two Standard Model 4½" Otis Production Packers Turned Down To 3.67" O.D. And Set in 5" Drill Pipe

HOUMA, LA. – Otis packer specialists from the Belle Chasse and Houma divisions recently solved an extremely difficult well completion problem for one of the major producing companies in their area, by turning down and setting two of their standard model 4½-inch Type WA Production Packers between tool joints in stuck 5-inch drill pipe. The fact that these packers could be turned down from their normal 3.80-inches to 3.67-inches and set in 4.30-inch I.D. pipe, saved the operator a considerable amount of rig time in addition to the cost of having special packers designed and built.

Well conditions at the time the Otis specialists were called in were as follows: 12,500 feet of 5-inch, 19.50-pound drill pipe had become stuck in a salt water flow during final drilling operations and could not be freed. As a result, the pipe had been cemented in place at that depth and cut off at 2900 feet, then tied back to the surface with 7-inch, 29-pound casing. The only potential producing interval was located at 11,600 feet. Before attempting to bring in the well, the operator wanted to plug below, and set a packer above, the potential zone.

Probably the most serious problem facing the Otis specialists on this particular job was the fact that the operator wanted the packers set in the pipe between tool joints. This meant any packer run into the well would have to have an outside dimension of less than 3.75-inches to pass through the tool joints, yet have a sufficient range to set and hold in the 4.30-inch I.D. pipe. Although none of the standard production packers or bridge plugs available today are designed to cover this range, the Otis specialists felt confident their packer could be turned down and run. In the interest of time and cost, the operator agreed to try it.

After first running a 3.68-inch O.D. junk basket to 11,800 feet, the first Otis packer, equipped with an expendable sealing unit, was run in to 11,744 feet and set. In that this packer was to serve as the bridge plug, it was set 4 feet below a tool joint so that the cement to follow would straddle the joint and give a stronger plug. Running time was approximately 5¾ hours, due to the viscosity and weight of the drilling mud. Once set, three dump bailer loads of cement were placed on top of the packer and allowed to set for 12 hours. At the end of that time, the plug was tested to 3500 p.s.i. Where fluid had been lost through the bit prior to plugging, there was no bleed down of pressure.

Next, the drill pipe was perforated and squeezed below and above the intended producing interval and the zone itself perforated. With these operations completed, another turned-down Type WA Packer was run and set between tool joints at 11,570-feet. A successful test to 1500 p.s.i. convinced the operator the packer would hold and swabbing operations to bring in the well were begun.

The help given this operator by his local Otis packer and completion specialists is typical of the service available from all Otis field personnel. Their knowledge of production problems and of the application, installation, and capacity of their equipment permits them to make sound, on-the-spot recommendations. The next time you find it necessary to consult with someone regarding packers or well completion techniques, call the Otis office nearest you or write Otis, Department 3-P, Box 35206, Dallas 35, Texas. You'll find experienced Otis well completion specialists ready to help you — anxious to serve you. © *1960 O. E. C.*

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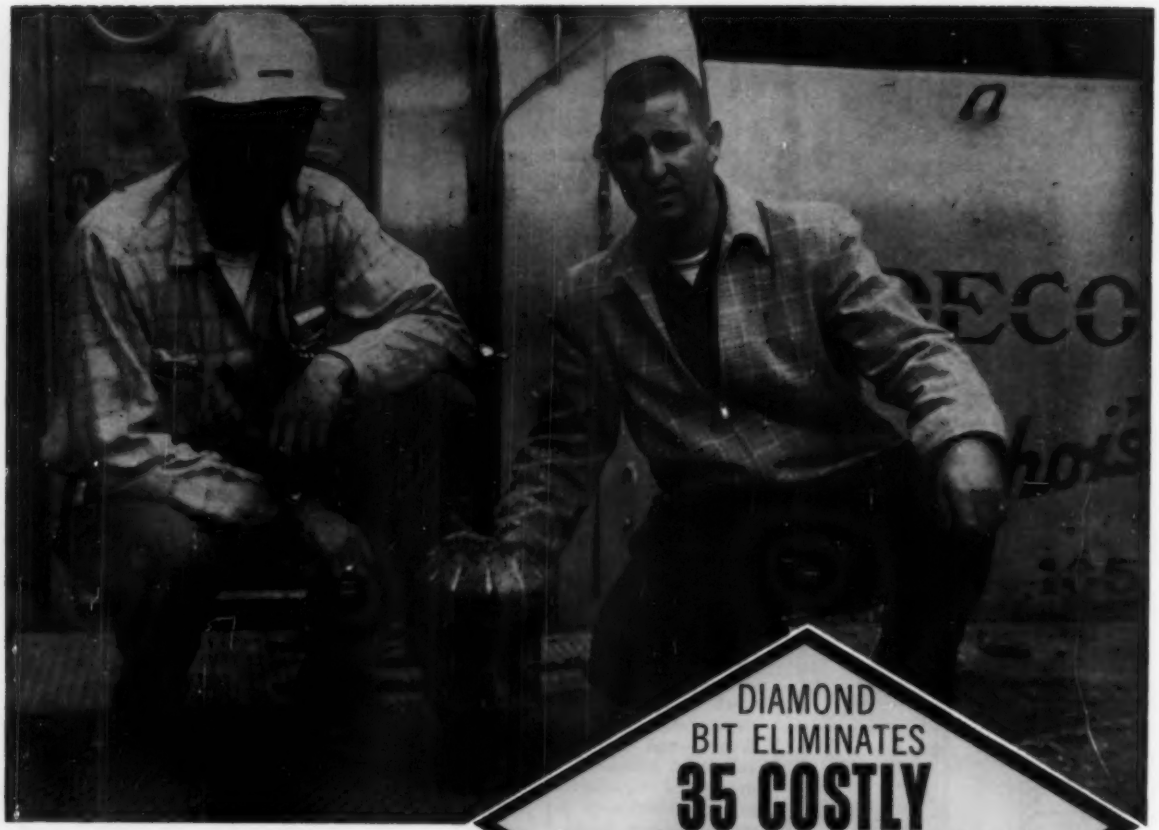

DIAMOND
BIT ELIMINATES
35 COSTLY ROUND TRIPS

Christensen Diamond Drilling Bit sets endurance record of 28 rotating days on bottom

The new record was set by a major oil company using an 8-11/32" Christensen diamond drilling bit in Natrona County, Wyoming. After 28 days rotating on bottom the bit was pulled at approximately 16,000 feet and found to be in fair condition. The operating company estimated that 35 round trips and 35 conventional bits would have been needed to drill the same intervals and that the diamond bit saved 18 days.

The bit operated under 10,000 to 16,000 pounds of weight at 53 to 57 R.P.M. The drill string consisted of 4-1/2" drill pipe, nine 7" collars with a set of jars. A second diamond bit had no trouble reaching bottom and ran for 16 rotating days, also surpassing the old 13 day record for the area.

For "Less Cost Per Foot" drilling, contact Christensen Diamond Products Company for information about its complete line of diamond bits and core barrels.

"Less cost per foot."

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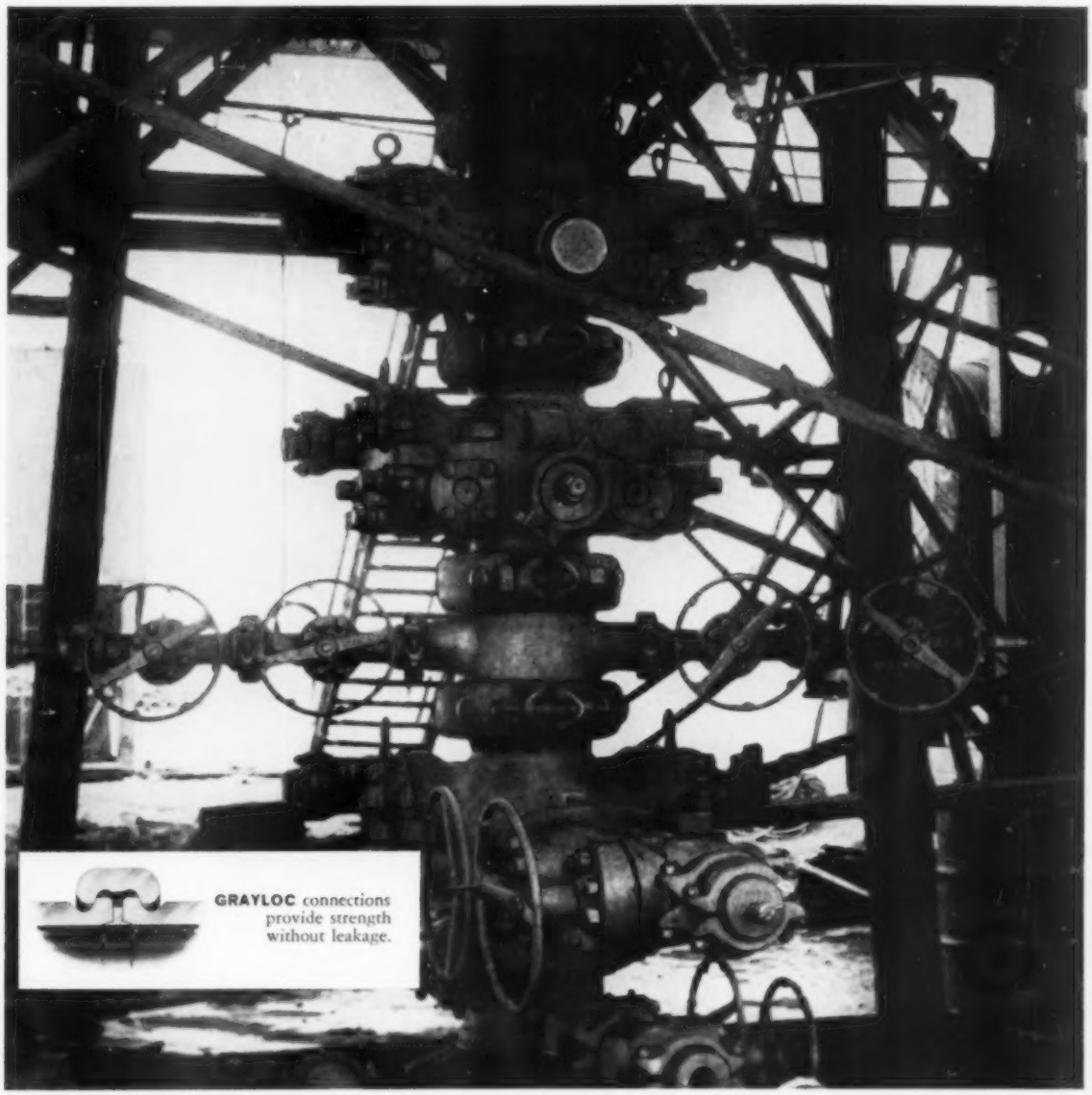

GRAYLOC on Well Head and Control Equipment Safely Withstood 7,300 PSI

This all Grayloc assembly, in use on a well in Eastern Venezuela, withstood well pressures of 7,300 psi during drilling operations — proving that Grayloc equipped assemblies provide the greatest possible blow-out protection. The assembly required no additional tightening after the original make-up.

It took a native crew less than six hours to nipple-up this Grayloc equipped well head and control assembly, and it required approximately 24 inches less substructure height than a comparable flanged hook-up.

Learn how Grayloc connections can save you extra hours and money on control systems with complete blow-out protection.

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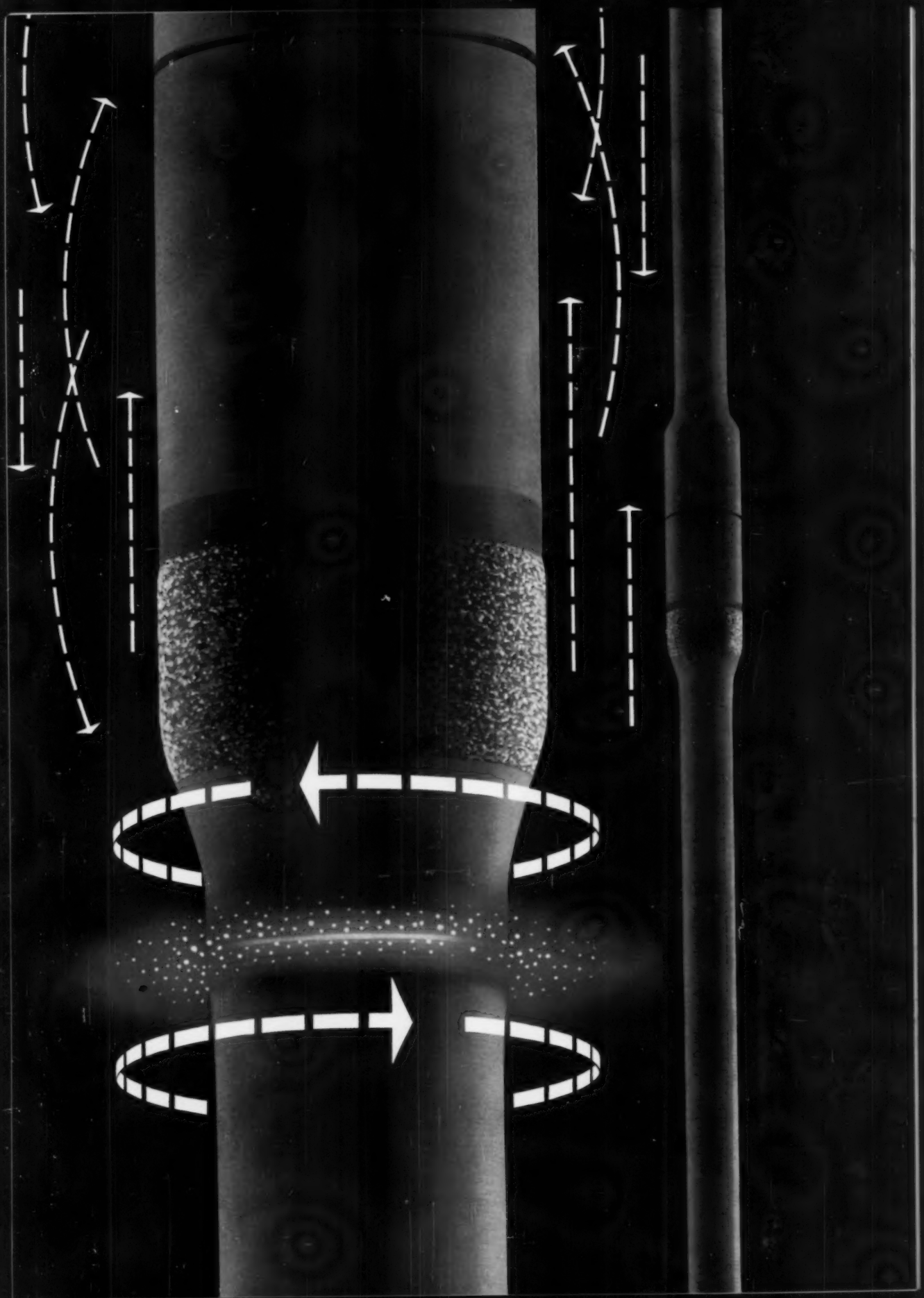


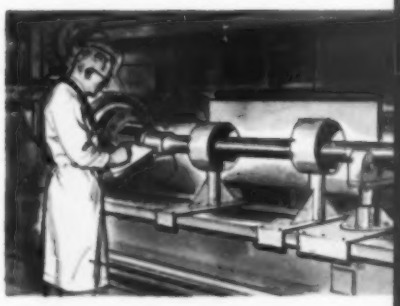
There has never been a field failure in the weld area of a Reed Flash Welded tool joint!

ANOTHER EXAMPLE OF REED LEADERSHIP IN TOOL JOINT DESIGN

For twenty-five years Reed has pioneered advancements in tool joint design—the Shrink-Grip joint which practically eliminated last engaged thread failures—the Internal Flush joint that became API Standard—the Double Streamline joint (the 4½" size later adapted as API Standard 4" Full Hole)—the Semi-Internal Flush joint (later called Extra Hole)—the Super Shrink-Grip joint with cylindrical land and fixed landing shoulder for foolproof field application and removal—the Wide-Open joint for light weight drill pipe—the "tensile impact" test for flash welds.

Reed research, engineering, and experience are your assurance of the very best in tool joints today *and* tomorrow.

When you buy your next string, remember this—Reed Tool Joints will outlast any others!



ask about the new Reed
Inarclad 60

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TOOL JOINTS

REED ROLLER BIT COMPANY
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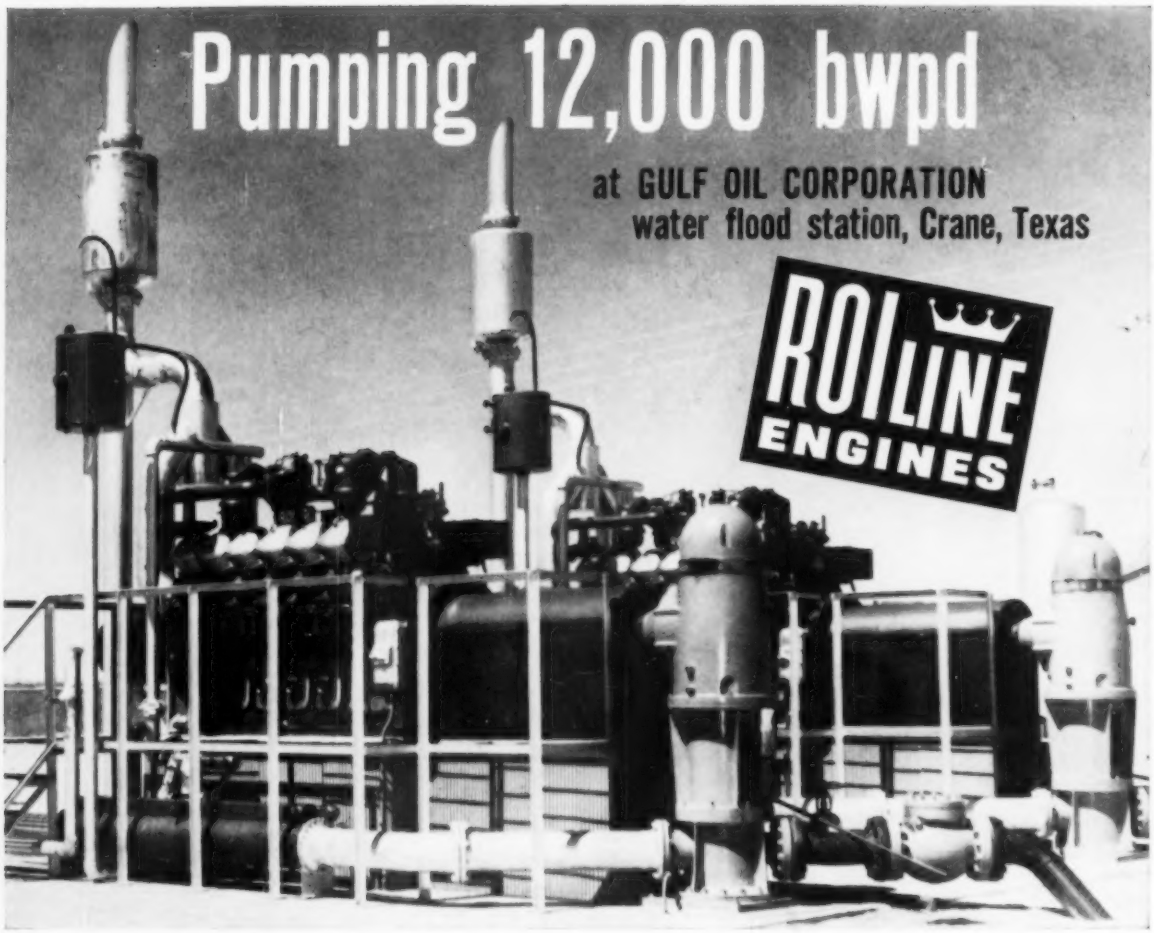
GULF COAST RECONDITIONING AND ROCKY MOUNTAIN DISTRIBUTOR FOR SMITH DIESCHER PRODUCTS

Pumping 12,000 bwpd

at GULF OIL CORPORATION water flood station, Crane, Texas



• At their water flood station, near Crane, Texas, Gulf Oil Corporation, Midland, Texas, is using ROILINE engines to pump 12,000 bwpd at 600 psi. The Johnson turbine pumps are driven by two Model L-3460 ROILINE engines, each delivering 325 hp at 1000 rpm burning natural gas. These are 12-cylinder V-type engines of 3468 cu. in. displacement with a 7¼-in. bore x 7-in. stroke (see illustration at left). Their modern, basically simple design means all-around dependability combined with high fuel economy and long service life.

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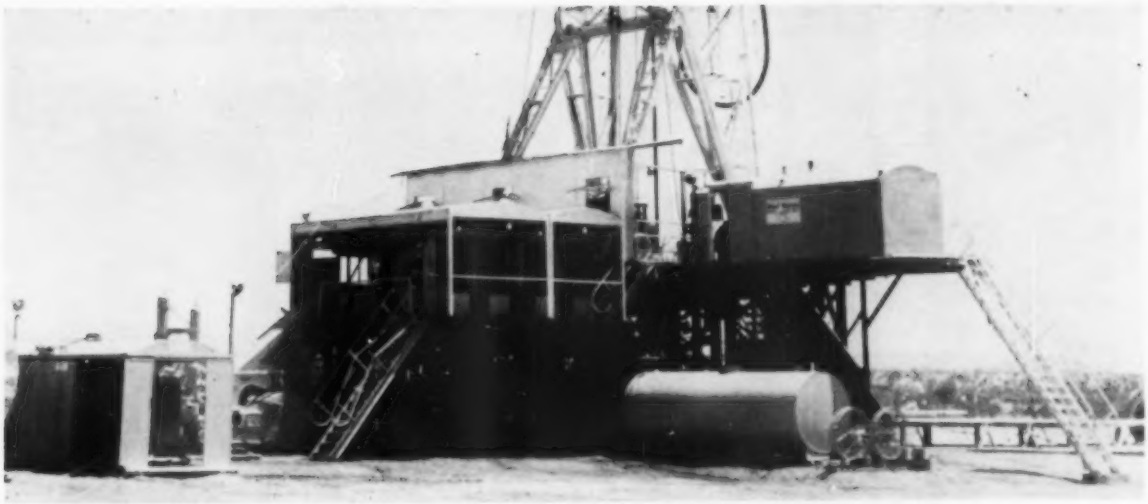


Packaging two engines in each shed makes readily-movable unit, facilitates handling during rig move.

Levelling drill site. Location where the rig is to be assembled must be leveled with a transit since the drawworks, engines and mast must be level to insure alignment. Use of a location plan or sketch of the rig layout is very helpful in setting the rig equipment when it is unloaded at the location (See Fig. 1).

Plates on Substructures

Most substructures today are plated on the bottom with ⅜-in. or ½-in. metal plate, which eliminates the use of matting boards.

The old-style narrow box substructure may be plated wide enough for sufficient load-bearing surface by building an outrigger on each side (See Fig. 2). This also permits easier handling with trucks because of the extra width, which prevents the substructure half from turning over.

Slush pumps may be plated to eliminate the matting boards, also. Both slush pumps and substructure will remain level better than when set on matting boards and the mast will be level when in the raised position if the substructure is level.

Installing Heavy Equipment

Rotary table may be quickly set in the correct position for perfect alignment by using V-blocks. The V-blocks of 1-in. plate are welded to the rotary table support beams and the matching piece is welded to the side of the rotary table. Therefore, the rotary table is aligned when set in position. To insure quick-changing of the rotary sprocket, a quick-change type hub and sprocket should be used.

Drawworks is set on the floor and moved into correct alignment by using a forward and side stop welded on the substructure.

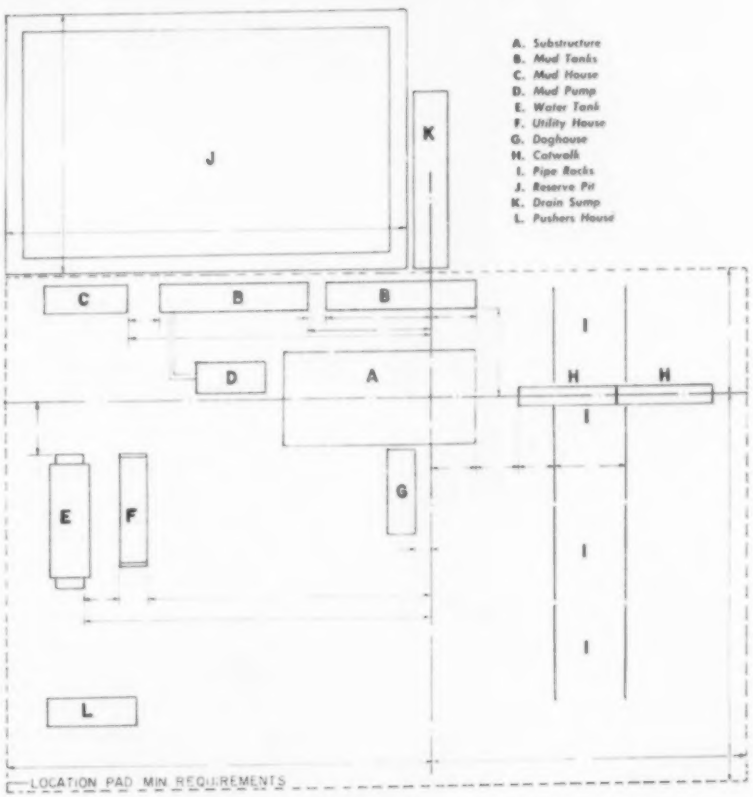
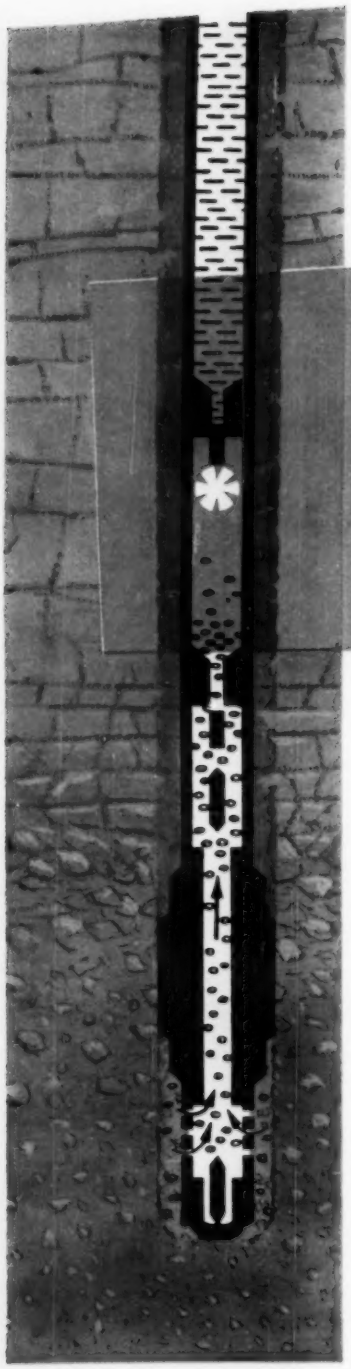


FIG. 1. Rig location must be leveled with a transit for correct alignment of equipment. Using a location plan or sketch of rig layout helps in setting rig equipment into pre-determined position rapidly on location.

Marvin T. Parker graduated from Kermit High School in Kermit, Texas, and afterward spent eighteen months employed in various phases of the petroleum industry. He served three years in the U. S. Air Force as a pilot. He was employed by Magnolia Petroleum Company as a driller's helper in 1949 before attending Texas Technological College in Lubbock, Texas. Parker graduated with a BS degree in petroleum engineering in 1952 and was employed by Great Western Drilling Company as an engineer trainee. His positions were crewman, driller, district drilling engineer, assistant district drilling superintendent, and chief drilling engineer. Parker is now manager of drilling for Great Western.



now! find low pressure payzones

. . . Regardless of Water Cushion

When testing deep formations, the hydrostatic pressure of the water cushion used to keep the pipe from collapsing can often hide potential production in a *low pressure* zone.

THE NEW HALLIBURTON RETRIEVABLE BACK PRESSURE VALVE can help avoid passing up these payzones by supporting the water cushion so its hydrostatic head does not affect the formation pressure recordings. The Back Pressure Valve is retrievable by wire line.

LOOK AT THESE RESULTS

On a recent West Texas test where the hydrostatic pressure of the water cushion used exceeded 900 psi, the use of the Back Pressure Valve allowed the operator to obtain the following formation pressure recordings from the zone tested:

Initial flow pressure	110 psi
Final flow pressure	303 psi
Closed-in pressure	566 psi

Since all formation pressures were less than the hydrostatic pressure of the water cushion, it is obvious that, without the use of the New Halliburton Back Pressure Valve, no formation pressure would have been indicated and this potentially productive zone might have gone undetected.

ASK YOUR HALLIBURTON TESTER ABOUT THIS NEW INNOVATION!

TESTING SERVICES

Another first in Formation Testing!

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String-up with QUALITY

Yellow Strand "POWERSTEEL"

In these days of deeper wells and faster line speeds, it pays to equip your rigs with Yellow Strand "POWERSTEEL" rotary drilling lines. Here's a built-in ruggedness to combat the shock, strain and wear of today's tough drilling . . . giving you maximum ton-mile service. "POWERSTEEL" rotary lines are made from wire having the highest tensile strength and wear resistance of any Broderick & Bascom wire rope. You gain the safety and assurance of high reserve strength, too.

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When a standard derrick and detached substructure is used, the alignment and spacing of the input chain is critical. This may be simplified by a pinned spacer beam on each side of the input chain. The center of the pin connection must be the same as the center of input and output sprockets.

After the substructure, compound, and engines are set, and the spacers pinned, then the distance between the output and input sprockets will be the same, regardless of variations in height. Spacers will rotate the output sprocket around input sprocket and insure the input chain and chain guard fitting each time the rig is assembled.

Unitizing Equipment

Packaged engine shed. The engines and compound, which should be a sectional type mounted on each engine skid, are set and aligned by using dowell pins and welded stops.

Each engine skid has a section of the engine shed which makes the complete shed when all engines are in place (See Fig. 3). This eliminates the necessity of building a shed from individual sections. The engine shed outside wall and rig floor walls should be designed to pin together rather than bolt because any pin connection is faster to assemble than a bolted connection.

A pump belt guard of the trough design can be installed by the crews without a truck (See Fig. 4).

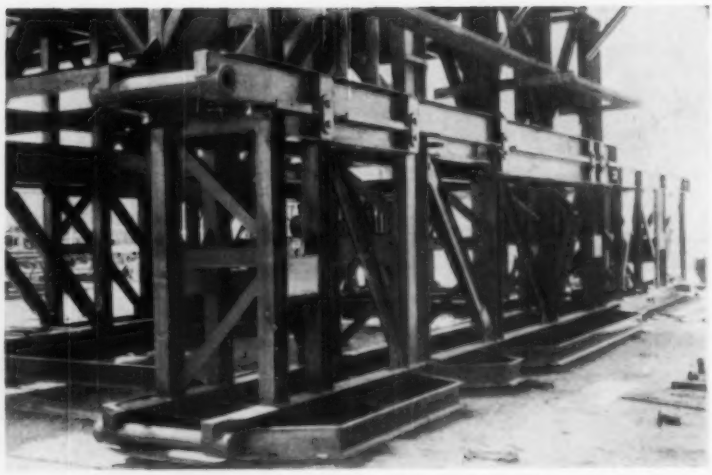
Mud tanks comprise a large part of the rig and may require excessive time to rig up if not properly designed as a unit. The shale shaker is mounted so that it can be moved in place with all the plumbing fixed. Mud jets swing back over the tank and are moved without being disconnected.

Mud tank and suction risers are mounted permanently in the mud tank. Suctions and mud flow connection utilize a pneumatic-type connection for fast assembly that will seal properly with some misalignment.

A sample house built into the body of the tank on either end will eliminate moving another house.

If the substructure is not high enough to permit setting the mud tank bottom at ground level, a sling should be made on the loading hitch. This sling of wire rope should be permanently installed and hooked on the top of the mud tank above ground level. This simple hook-up will speed up rig-moving since the loading hitch on the bottom of the mud tank will not have to be dug out by the crews in order to secure the truck winch line.

A utility house and storage house may be designed into one unit which will eliminate one load. The light plant, air compressors, water pump and air volume tanks mounted in the utility



Outriggers added to old-style narrow-box substructure and metal-plated underneath give sufficient load-bearing surface, prevent substructure from turning over during moving.

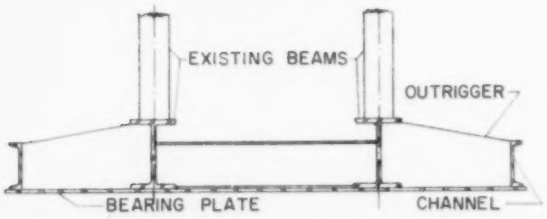
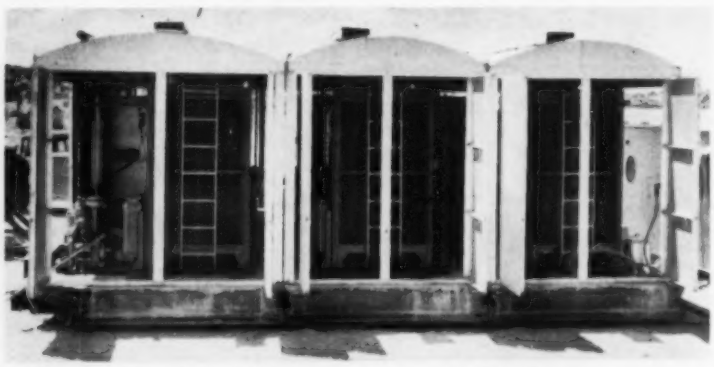


FIG. 2. Metal plates applied to substructures replace matting boards, allowing easier handling.



Skid-mounted engine house for electric rig form complete units for transporting and easy alignment at new location.

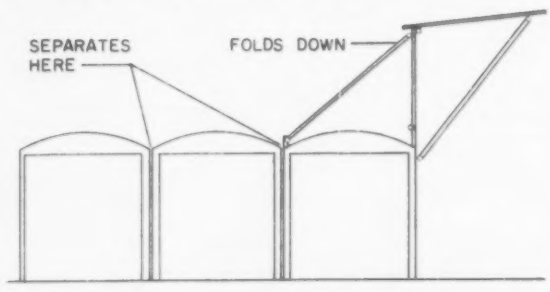
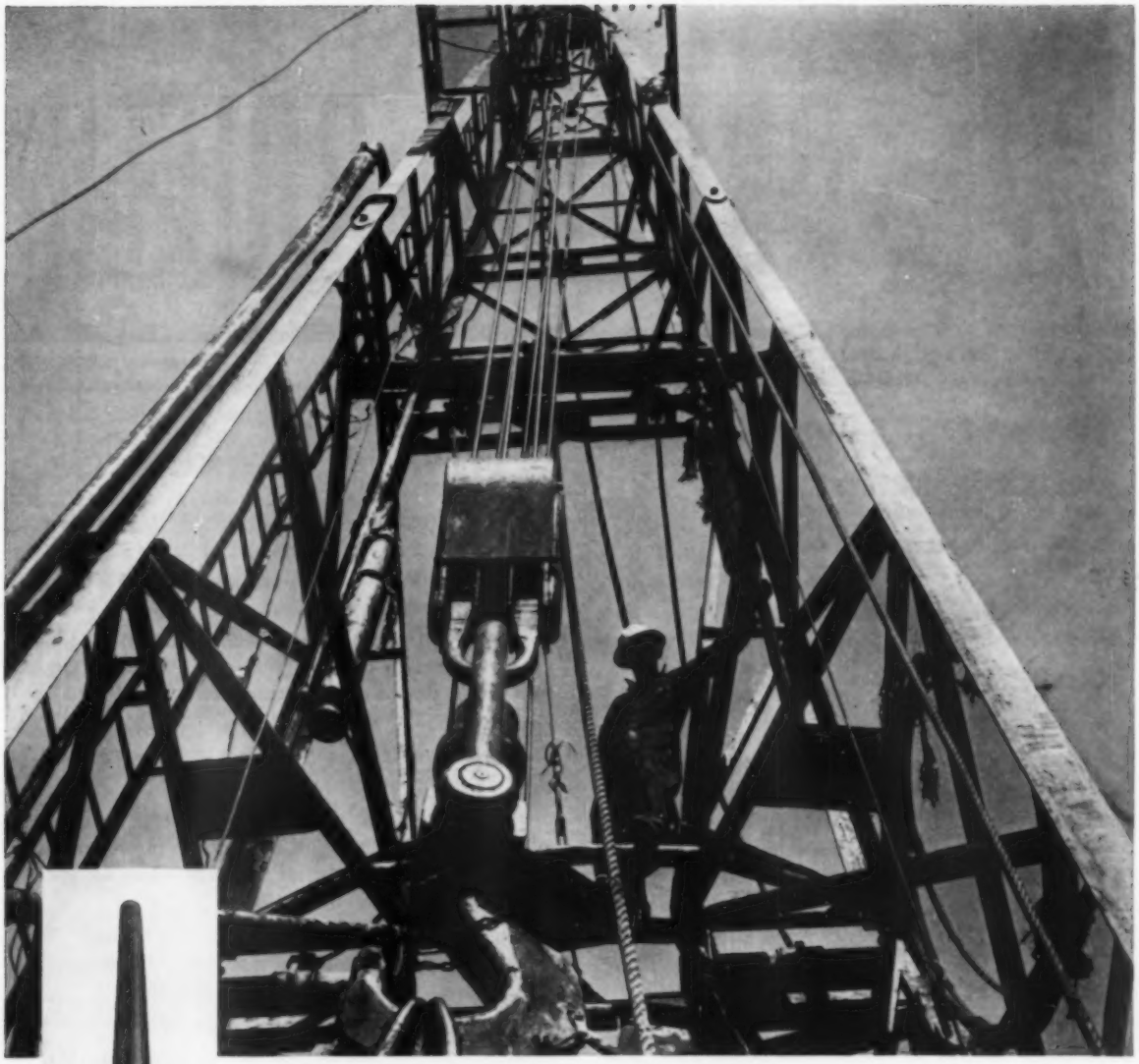


FIG. 3. On rapid-move engine shed for dual-level substructure, each engine skid has a section of the shed attached. Placing engines assembles complete housing, eliminating building shed from individual sections.



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DRILLING BRIEFS

DRILLING MUD DATA — REPORT 60-4

DRISCOSE* Lowers Drilling Costs . . . Letters tell us why!

Since we started these bi-monthly newsletters, we've been getting many reports from the field with drilling case histories and anecdotes of our products in action. Here is the substance of some recent letters that we'd like to pass along.

North Texas Mud Program A Big Success.

A Texas mud engineer has written us about the success of our North Texas mud program. This Driscose low-solids mud program was prepared at the request of an operator in the area and was based on a test well representative of the locality. Comparison with three nearby wells using different programs showed drilling savings of $7485, $5243, and $4864. In all three comparisons, reduced drilling time and lower bit costs using Driscose accounted for most of the savings, although in two instances, mud costs for the test well were also less.

The low-solids system using Driscose has a low mud weight (9 lbs.), low gel strength, and a fairly low viscosity. In addition to providing increased penetration rates, these conditions also keep mud losses to a minimum — especially in the 4200- to 4800-foot region where fluid losses had previously been high.

Because of the success of the Driscose test well, our "mud guide" is now being widely followed throughout North Texas. While the mud engineer on the job must make the "decisions of the moment" (changing viscosity, chemical treatment, etc.) to suit the particular well, the "guide" specifies such factors as: percent of oil (up to 4%) . . . the rate of adding High Viscosity Driscose (100 lbs. per drilling day from surface pipe to TD) . . . basic chemical treatment (caustic, soda ash, thinners) . . . top limit of mud weight (9.6 lbs./gal. below 4200') . . . table of best funnel viscosities for various depths (from 32 at surface pipe to 125 at 7000 feet) . . . recommended viscosity for running logs and casings, etc. This North Texas mud program will be furnished upon request. Let us know if you're interested.

Comments from Louisiana

The following comments are quoted from recent letters received from Southern Louisiana operators.

DISTRICT ENGINEER SAYS: (St. Mary Parish) "Wall cake was reduced from 1/16" to 1/32" after we started decreasing chemical additions and using Driscose to control solids."

SUPERINTENDENT SAYS: (Vermilion Parish) "We figure we saved $2 000 on weight material by using Driscose in a gyp mud to suspend barite."

MUD ENGINEER SAYS: (Cameron Parish) "Driscose not only controlled water loss, but it actually reduced viscosity in a gyp-saltwater mud!"

DRILLING ENGINEER SAYS: (Offshore) "We tried other materials in both lime and low pH muds, and found the cost was twice as much as when we used Driscose."

CORROSION ENGINEER SAYS: (Lafayette Parish) "We had to displace clear fluids in 12 wells with a Driscose packer mud to help prevent pipe corrosion."

Big Savings Reported on Canadian Wells.

Letters from Alberta tell us of the effectiveness of Driscose low-solids mud systems in the Pincher Creek and Waterton Lakes areas. Here, Driscose low-solids programs have increased penetration rates, improved drilling conditions, and reduced over-all well costs. A cost comparison between a 6000-foot well recently drilled with Driscose low-solids mud (4 to 8% solids) and one of equal depth drilled with a higher-solids mud (10 to 17% solids) showed a $7940 net saving. This saving is even more remarkable in that the well selected for comparison was one of the fastest drilled in the area before the introduction of Driscose low-solids mud.

Performance counts . . . and Canadian operators report that Driscose low-solids muds are now accepted procedure in the area.

*Driscose is a trademark for Sodium Carboxymethylcellulose.

DRISCOSE

DRILLING SPECIALTIES COMPANY

Bartlesville, Oklahoma

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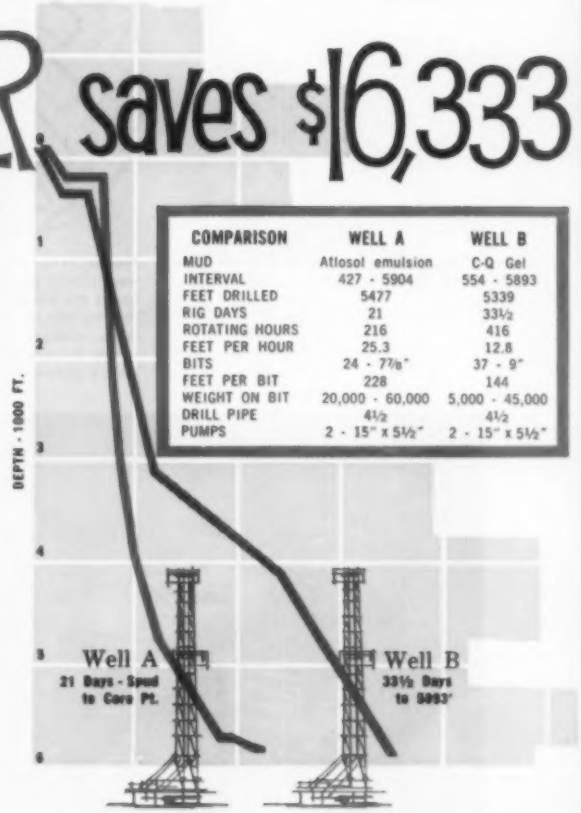
Faster Drilling-Fewer Bits

ATLAS EMULSIFIER saves $16,333

Faster drilling on Big Horn Basin Well, Big Horn County, Wyoming, cut rig time by 12½ days and required 13 fewer bits than offset Well B . . . both contractor and operator attribute savings directly to the mud program utilizing an Atlas emulsifier. Both wells were drilled with the same size equipment and under equivalent conditions. The mud program for Well A, however, was in sharp contrast to the high-solids, high-weight, high-viscosity muds generally used in this area. Acclaimed as the best-drilled well in the area to date, Well A used a low-solids oil-in-water emulsion with an Atlas emulsifier. This low-viscosity, low water-loss fluid maintained a trouble-free open hole, brought up clean cuttings and made the savings possible . . . a total of $16,333 in rig time and bit costs.

COMPARISON	WELL A	WELL B
MUD	Atlosol emulsion	C-Q Gel
INTERVAL	427 - 5904	554 - 5893
FEET DRILLED	5477	5339
RIG DAYS	21	33½
ROTATING HOURS	216	416
FEET PER HOUR	25.3	12.8
BITS	24 - 7⅞"	37 - 9"
FEET PER BIT	228	144
WEIGHT ON BIT	20,000 - 60,000	5,000 - 45,000
DRILL PIPE	4½	4½
PUMPS	2 - 15" x 5½"	2 - 15" x 5½"



Atlas emulsifier is sold through distributors under these tradenames . . . each is the product of Aquaness Department, Atlas Powder Company:

TRIMULSO®

Distributed by Barold Division, National Lead Company

Registered trademark Barold Division, National Lead Company

DRILLING MILK

Distributed by Magnet Cove Barium Corporation

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Drilling Milk
A SPECIAL EMULSIFIER FOR CLEAR WATER DRILLING AND LOW SOLIDS FLUIDS
MAGNET COVE BARIUM CORP. HOUSTON, TEXAS

ATLOSOL

Distributed by Milwhite Mud Sales Company and other selected mud companies

Registered trademark Atlas Powder Company

ATLAS EMULSIFIERS IMPROVE A GOOD DRILLING FLUID

Because Atlas oil-in-water emulsion muds provide better oil action, they improve hole conditions, extend bit life, and increase penetration rates.

Better Hole Conditions. Atlas oil emulsion decreases torque as much as 50% . . . the hole is kept cleaner and pump pressures are correspondingly lower. There is less danger in lost-circulation and low-pressure zones.

Longer Bit Life. Atlas oil emulsion prevents balling, provides better cutter and bearing lubrication. Greatly extended bit life reduces bit costs, reduces rig hours lost to trip time.

Faster Drilling Rates. Atlas oil emulsion makes more feet of hole per hour. Oil lubrication combines with improved hole condition to increase drilling rates in competent and troublesome formations.

Aquaness CHEMICALS
ATLAS POWDER COMPANY

Aquaness Department, Atlas Powder Company

P. O. Box 21072 • Houston 26, Texas

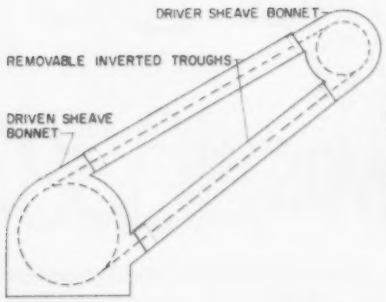


FIG. 4. Trough-design pump-belt guard can be installed by crews without using a truck.

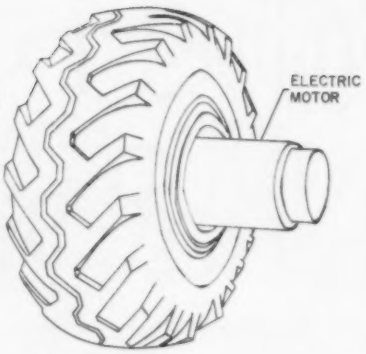
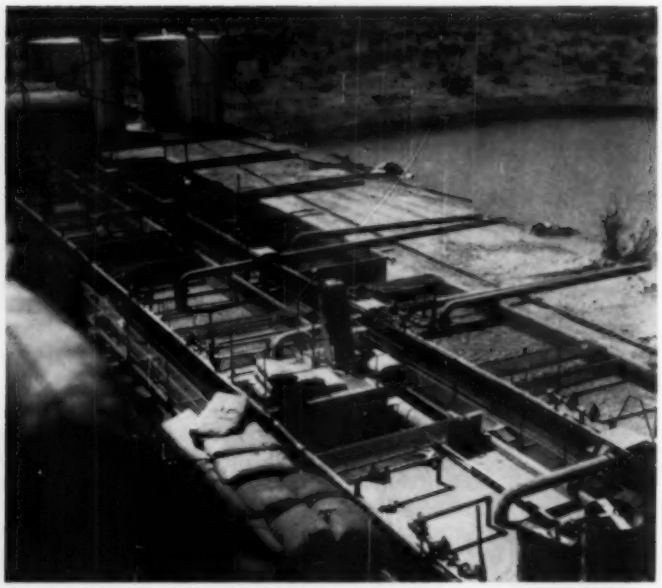


FIG. 5. When moving in remote areas of the world, large electric-wheel high load-capacity trucks are being used to move larger units of drilling intact. Equipment transports heavy loads, without necessity for building roads, across terrain where large rocks, trees, and severe grades have been removed.



Unitizing mud tanks saves considerable time in moving since they comprise a large part of rig and may require excessive time to rig-up if not properly designed as a unit.

house will save time handling each piece of equipment separately.

A well-designed water storage system consists of at least two 500 bbl horizontal skid-mounted water tanks. The horizontal skid-mounted tanks are easier to load on a truck, move and set at the new location. The plumbing, including the overflow, is an integral part of each water tank. The skids may be made about 4 ft longer so that a freeze box may be constructed around the outlet valve for cold weather operation.

Mud storage house is usually empty during moving and may be easily utilized for storing hoses, canvas windbreaks, and other lightweight or easily-damaged equipment. A lightweight box large enough for all the light fixtures and designed to fit into the mud house, protects the light system while moving.

Checking Final Assembly

After the major equipment has been set, details of final assembly are quite often very time-consuming.

When substructure has been centered exactly over the stake, and the rotary table set, then the process of alignment begins. The drawworks rotary output sprocket should be checked for alignment with the rotary table sprocket in order to catch any misalignment that resulted from damage during the move. The input chain from the compound to the drawworks should be checked for the same reason.

Engine's clutches should be dial-indicated before operation to check any misalignment caused by moving. All air clutches and flexible couplings must be aligned within .005 to .010 of an inch to insure long life.

Setting drive belts. The slush pump belts should not be tightened until the mast is raised, unless the slush pump is chained to the substructure. This prevents stretching the belts and pulling the pump out of alignment if the rear of the substructure should be lifted off the ground.

The string method is usually used for aligning the pump driver sheave and driven sheave. This method is only as good as the judgment of the man who is looking at the string and it could stand some improvement.

Tension of the V-belts is important and they should be tightened when any belt can be pulled down about 4-in. with one hand.

The pump belts should always be placed in the grooves closest to the pump to reduce the load on the shaft and bearings, and any grooves in the sheave not used should be on the outside of the sheave. All pumps must be levelled and kept level to eliminate adverse stresses in the power end. The pumps, like any of the other equipment, should not be dropped when loaded or unloaded.

Fitting systems together. The air, water, fuel, and electrical systems are a very important factor in any rig move and they must be planned carefully.

The location plan helps in having each piece of equipment set exactly in the same spot to insure that all of these systems will fit together without any time-consuming modifications.

Other Aids to Fast Rig-Up

Use of air hoists can make any rig-up faster and safer. Since the cathead is not available for use until the engines are started, an air hoist supplied by a compressor in the utility house can be used to move a great deal of small equipment into place.

An air hoist is very helpful also in handling equipment on the V-door side of the rig. Smaller equipment on the pump and mud tank side of the rig may be handled without a truck by a swinging 270 deg arc boom attached to the mast or derrick leg.

When a boom is used, the off side cathead serves as the power source. One type of boom consists of a 25-ft length of 4½-in. drill pipe with a sheave on each end and one end clamped to the mast or derrick leg.

A wire line from the top of the mast or derrick is used to hold the boom at the desired angle. A ½-in. or ⅜-in. soft-lay wire line with a rope on the cathead end is used to reeve through the two sheaves for hoisting.

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THE EYES OF THE OIL INDUSTRY

SCHLUMBERGER

How one operator used D-Gassers to

reduce gas well costs by about $55,000

A Canadian operator — drilling deep gas wells in the Alberta foothills — is using the SWACO D-Gasser to save about $55,000 per well. Here is how he does it:

This operator, who was developing a gas field in the Alberta foothills, was encountering a gas-cutting problem during drilling that increased costs seriously. The problem was high-pressure, low-volume gas accumulations in a shale section above the main pay or between pay zones.

Until this shale section was reached, mud weight of 10 pounds per gallon was carried. When this section was being penetrated, however, severe gas cutting and "blowing" occurred. The gas cutting then persisted in the form of a two to three hour trip gas for the remainder of the well.

Practice before using D-Gasser

The operator circulated until he could build mud weight up to 11-13 pounds per gallon to control the gas cutting. Lost circulation in the pay section frequently occurred with the heavy mud, and a great deal of lost circulation material was often required. The cost of mud materials to control both gas and lost circulation ran $25,000 or more per well.

Initially, it took anywhere from two days to a week to condition the mud, and in one case it was necessary to set casing before drilling could proceed. In addition, several hours of rig time were lost after each trip gunning out the trip gas.

Practice when using D-Gasser

With a D-Gasser installed, the operator merely starts it up when the gas cutting occurs. Occasionally the preventers have to be closed, and the well placed on choke for a few hours. However, the whole job of mud conditioning can be accomplished in less than one day without increasing the mud weight. Moreover, penetration rates and bit life while drilling using the lower weight muds are substantially improved. Total savings in drilling costs amount to approximately $30,000 per well.

To summarize, the operator has found he saves $25,000 or more in mud costs and something like $30,000 in rig time and other drilling costs.

This case is just one of many examples that prove the SWACO D-Gasser is more than just a safety device to be used for wildcat drilling. It makes possible important reductions in overall well costs in any area where gas cutting is a problem. Contact your nearest SWACO representative to find out just how much D-Gassers can reduce your costs. Also ask him how SWACO Clayjectors and D-Sanders can further reduce drilling costs.

SWACO

SALT WATER CONTROL, INC.
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Drill pipe basket. On smaller rigs drilling 4000 to 6000-ft holes, a drill pipe basket will reduce time and expense in moving drill pipe. This basket constructed of drill pipe and placed beside the catwalk is used to hold the drill pipe when it is laid down before the move.

Cross pieces placed in slots across the top are used to extend the pipe racks over the basket to facilitate handling other tubular goods. After the basket is loaded, a truck can load the drill pipe intact and move it to the new location.

The pipe basket is then set beside the catwalk and the pipe removed as needed with a sling and the catline. As many as two pipe baskets on each side of the catwalk may be used if needed.

Skidding Rigs Efficient

Skidding method of moving drilling rigs was developed about 20 years ago and has progressed into a very efficient way of moving short distances over level terrain with soil that affords good bearing. The complete substructure with mast or derrick erect, drawworks, compound, engines and rig floor equipment are moved as one unit.

Substructure is jacked up, large skid beams are put in the substructure, the skid beams set on wide track dollies and tread-type tractors are used to tow the rig to the next location.

This method is less expensive than complete disassembly and usually saves one or two days moving time. The engine clutches should be checked after each move to insure that no misalignment has resulted during the skid move.

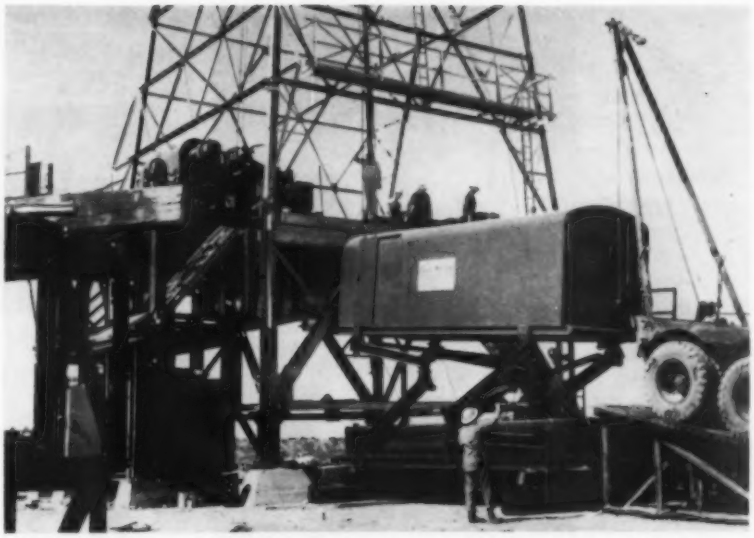
Using New Concepts

Moving and assembly methods used today are by no means the answer for the future. Deeper drilling requirements which will necessitate greater equipment restrictions on highway loads, and increased moving costs will force the operator of drilling equipment to be constantly alert for a better and more economical method.

Introduction of the lightweight alloy structural materials has given the engineer a new design tool and should result in less rig weight to perform the same job. The manufacturers that keep the weight of their equipment at a minimum will have a definite advantage over their competitors.

The electric-drive rig has made a comeback in the last few years and has solved some mechanical drive problems. Wells requiring more blowout preventor equipment have made it necessary to increase the height of substructures.

Problems regarding input chain length, excessive pump belt length and loading the compound, engines and drawworks on the floor all become major.



Using unique folding legs on doghouse points out how planning every aspect of rig move can cut overall moving time and reduce costs.

Utilizing a step-down substructure has helped in loading the equipment on the floor and in keeping the pump belts as short as possible. An excessive step-down distance increases the problem of input chain length and may require a jackshaft between the compound output shaft and the drawworks input shaft. The length of the pump belts should be kept under 600 inches to insure good service.

An electric-drive rig can be utilized on any height substructure and the alignment problems are practically eliminated. Assembly time is decreased, since a plug-in connection is faster than a chain drive. All prime movers and generators are set on the ground, which eliminates the time required to load and align this equipment on the substructure.

Electric-wheel trucks. Some new concepts have been introduced when moving in some remote areas of the world. The large electric-wheel high load capacity trucks are being used to move larger units of the drilling rig together (Fig. 5). This equipment was designed to transport heavy loads, without building roads, in desert areas and over other trails where the large rocks, trees, and severe grades had been removed.

On these trucks the large wheels have low-pressure tires, wide-tread widths, and an individual electric motor built in each wheel. The power source is an engine and generator set with an electric conductor to each wheel motor.

Possibility of designing a rotary rig around this electric wheel drive for faster moving is not too far-fetched. The truck could be an integral part of the rig with the rig power furnishing the power to the electric wheels for moving. Some modification of present-day substructures may be possible to utilize the electric wheel for "rig-skidding" and then removed for other applications.

Some of the large-capacity trucks that are on the market today might be utilized to move a complete mast strung up with blocks and drilling line if the mast could be modified with strengthened angle braces so that it would be supported by the rolling tail board and headache rack.

All auxiliary equipment could be skid-mounted on large skids and the number of loads decreased. Possibly the truck could be designed to be coupled up short with a blade on the front for clearing roads and making locations.

Conclusion

Designing of rotary drilling equipment for moving and the moving of this equipment was an art rather than a science until the past few years. Design engineers have introduced many time-saving ideas, designed equipment for faster moving and assembly, and the end result has been lower moving costs for rotary drilling rig operations.

Demand for better-designed rigs for economical moving will be greater in the future and it is a field where a great amount of improvement is needed.

Acknowledgement is made to R. C. Tucker, president of Great Western Drilling Company for permission to publish this article, and to Louis P. Nell, rig-up and design engineer, Great Western Drilling Company, whose assistance in preparing this paper was invaluable.

★ ★ ★

The proper chemical correctly proportioned ***HERE***

...And used for minimum treating cost of low cuts, as indicated ***HERE***

...Results in a favorable sample ***HERE***

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TF-60-1

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report

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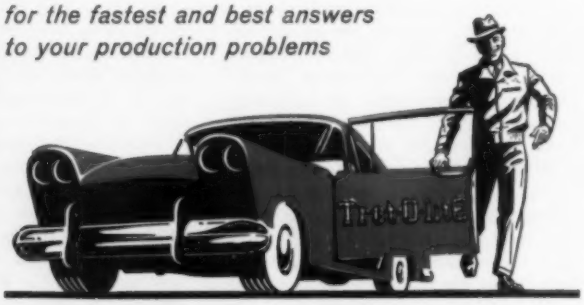

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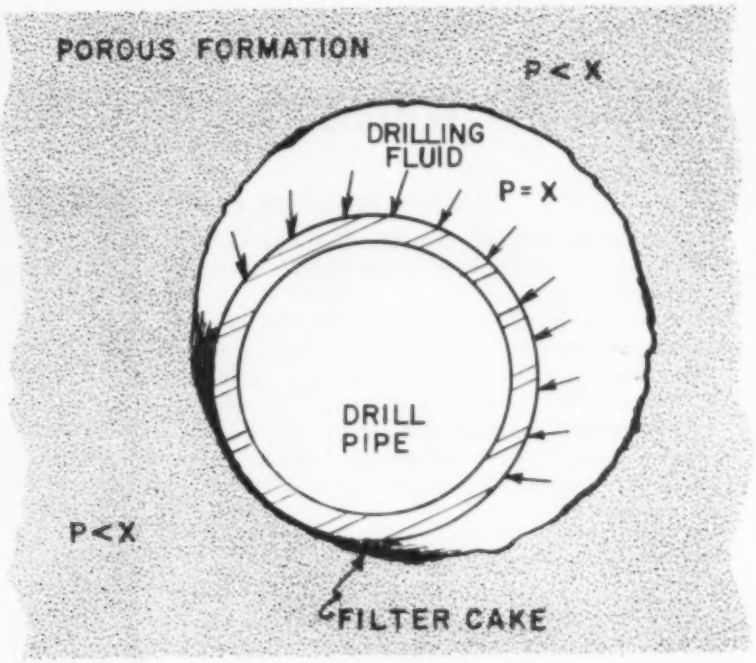


FIG. 1. **Differential pressure sticking** of pipe is the result of difference of pressure inside a bore hole (P=X) and in the surrounding formation of (P < X). If pipe is allowed to rest against wall of the hole, pressure drop can hold the pipe with great force.

Novel fishing job . . .

drillstem tester frees stuck pipe

B. J. SARTAIN
The Atlantic Refining Company
Casper, Wyoming

Pipe stuck by differential pressure is released with drillstem testing tool . . . might lead to new hydraulic fishing tool

A DRILLSTEM TESTING TOOL accomplished in one run what $13,000 worth of conventional fishing did not. The unusual job was performed in The Atlantic Refining Company's No. 1 Anton Eberts, located in Stark County, North Dakota, to free pipe stuck in the hole by differential hydraulic pressure.

What is Differential Sticking?

After a permeable, relatively low-pressure formation is penetrated by the drill string, a pressure differential from the bore hole to the formation exists, resulting in a relatively high flow of drilling fluid or filtrate into the formation. If the drill string (pipe or collars) is allowed to rest against the wall of the hole in the permeable formation, pressure differential will hold the pipe against the wall of the hole (see Fig 1). Further loss of filtrate to the formation will cause an accumulation of mud cake which acts as a pressure seal between the pipe and borehole wall and increases the effectiveness of the pressure differential. In addition, the thick mud cake contributes to the mechanical sticking of the pipe.

The question of differential pressure sticking of drill pipe has been the subject of much discussion by drillers, with some experienced drilling personnel even denying that the problem exists. Although the phenomenon is difficult to confirm with actual measurements, the theory is sound and field experience points to its validity.

Atlantic's Fishing Job

Atlantic's stuck pipe problem in the No. 1 Anton Eberts began when the pipe stuck after pulling up to make connections with a core barrel at 7959 ft. The drilling fluid was a comparatively high-solids, gyp base, oil emulsion mud. Drill string stuck with the core bit 40 ft off bottom and the stuck point was determined to be at 7440 ft.

First, 70 bbl of oil was spotted in an attempt to work the pipe free. This method had been successful in freeing stuck pipe twice before while drilling this hole. After working unsuccessfully for 36 hr, the pipe backed off at 7417

A TALE OF TWO FLOODS

HOW TWO WATERFLOOD OPERATORS INCREASED

CASE NUMBER ONE

This major oil company, operating a shallow waterflood unit, was experiencing severe declines in some producing wells.

In 1956, five wells were fractured. Production increases were so encouraging that the fracturing program was continued. Results have been analyzed only through 1958, but recent experiences have been at least as good or better than earlier results.

During the three years under study, 52 producing wells were fractured by Dowell and 6-month tests were obtained.

Production before fracturing averaged 2.1 bopd for all 52 wells. Six months after fracturing, production averaged 19.5 bopd—an average increase of 17.4 bopd or a percentage increase of about 930 per cent.

In addition to the producing wells, many injection wells were also fractured so that increasing volumes of water could be handled with a minimum addition of wells and pumping equipment.

Three-month reports are available on 20 such injection wells. Before fracturing, the wells would take an average of 44 bwpd at line pressure. Three months after fracturing, they would take an average of 202 bwpd—a 4.6-fold increase.

No exact monetary value can be placed on this increase, but it is obvious that the system could handle more water without increases in equipment and power requirements.

CASE NUMBER TWO

This independent operator started flooding a Bartlesville sand pool that had been abandoned. The field was originally opened up in 1917 and had been depleted by primary methods.

Early in the flood, the operator found that conventional five-spot flooding of the central part of the pool did not yield economical production. A general policy was developed to inject water in the central part and drill producing wells around the periphery.

Apparently there was still considerable oil in place along the edges, but the relatively tight formation prevented profitable producing rates without fracturing.

In 1952, the first two fracturing treatments were performed. Results were so encouraging that a systematic program of drilling and fracturing was started. By

THE STORY AT A GLANCE

- Location — **Eastern Kansas**
- Operated by — **a major oil company**
- Number of fracture treatments — **52**
- Average production per well before fracturing — **2.1 bopd**
- Average production per well **six months** after fracturing — **19.5 bopd**
- Average per cent increase in production — **930 per cent**
- Approximate cost of all treatments — **$27,000**

MORE IDEAS FROM DOWELL

TO HELP INCREASE PROFITS FROM SECONDARY RECOVERY

MAGNESIUM PELLETS

are often pumped into the formation before acidizing to heat the acid and melt away heavy hydrocarbons that might be blocking either injection or production. These treatments have proved remarkably successful.

ROCKSHOCK*

(Implosive formation treating service) is proving valuable both for formation cleaning and fracture initiation. It often makes possible the fracturing of formations that could not otherwise be fractured.

EZEFLO*

is a new Dowell surfactant. Available in bulk, it is especially useful for lowering water injection pressure. It is suitable for any use where an efficient, concentrated nonionic surfactant is indicated.

PROFITS WITH DOWELL STIMULATION SERVICES

THE STORY AT A GLANCE

- Location – **Eastern Kansas**
- Operated by – **an independent producer**
- Field had been abandoned before waterflood started
- Number of fracture treatments – **34**
- Cumulative production from fractured wells* – **866,512 barrels**
- Cost of fracturing* – **$25,828**
- Fracturing cost per barrel of oil – **3 cents**
- Fracturing cost as a percentage of total production cost – **less than two per cent**

*to December 31, 1959.

the end of 1959, 34 frac jobs had been performed at a total cost of approximately $25,828. All but a few of the earlier jobs were performed by Dowell.

Fracturing fluids, sizes of jobs and techniques were modernized and improved, as the program continued, to assure the operator of the greatest possible return on his investment.

Cumulative production from these wells totaled 866,512 barrels by the end of 1959. The net sales price of the oil was in excess of two million dollars. Cost of the fracturing treatments amounted to 3 cents per barrel of oil produced or less than two per cent of the total cost of producing the oil.

For this two per cent, the operator changed a flood that was headed for economic failure into an excellent financial success.

These field studies are just two more examples of how Dowell services can help operators improve production, keep down costs, improve profits and speed payout on investment.

You may run into a wide variety of problems in addition to oil production when you operate water disposal, gas injection or waterflood facilities. Your Dowell representative has a wide variety of services and products—both new and old—to help you solve your problems. A few examples are noted in the box below.

In addition to those services mentioned here, Dowell offers the Frac Guide*, the Acid Guide*, Cealment*, Corban* and Freflo* to help solve problems of secondary recovery. For more information on how Dowell can help you increase profits from your secondary recovery, pressure maintenance, water disposal or gas injection projects, **dial Dowell.** Dowell services and products are available from more than 150 offices and stations in the United States, Canada, Venezuela, Argentina and Germany. Dowell, Tulsa 1, Oklahoma. *Dowell Trademark

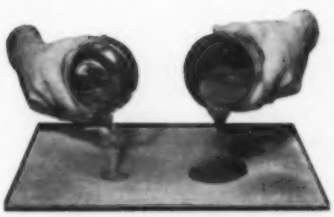
Services for the oil industry

DOWELL

DIVISION OF THE DOW CHEMICAL COMPANY

ABRASIJET*

(Dowell-developed abrasive jetting service) can be used to initiate fractures, perforate or clean the formation face. On injection or disposal wells the result is often a good increase in receptibility and/or a lower injection pressure. On producing wells, the results have been higher production, better gas/oil or oil/water ratios or improved results from fracturing or acidizing.



STABILIZED ACID

is regular acid with a special addition agent to prevent the deposition of gummy iron or aluminum hydroxides which might otherwise plug formation pores.

GYPBAN*

is a Dowell agent that is used to prevent formation plugging by water-formed gyp deposits. It is oil-insoluble and dissolves only gradually in water, thus providing months-long protection.

ft leaving fifteen 6½-in. OD drill collars (440 ft), the 5 9/16-in. OD core barrel (57 ft), and the 6⅝-in. diamond bit in the hole.

Company personnel were reluctant to run enough wash pipe to wash over the entire fish and felt that complete washover would not be necessary to recover the fish. During the first run with 248 ft of wash pipe, excessive pump pressures further discouraged running 450 ft of wash pipe.

Wash pipe used was 7⅝-in. OD by 6⅞-in. ID with 8-in. upsets. Since it was desirable to use a washover spear and not drop the fish to bottom, lighter wash pipe was considered inadequate to support weight of fish on the spear.

Two attempts to wash over and back off part of the fish failed. After both attempts, drill pipe and jars were run and the fish was caught after 6 to 10 hr spent in unplugging the top of the fish, but efforts to back off under these conditions were unsuccessful.

Use of Drillstem Test Tool

After these attempts to recover the fish with conventional fishing methods proved unsuccessful, a drillstem assembly was run. Benefit to be gained from this tool would result from the sudden decrease of pressure in the bore hole when the hydraulic testing tool was opened after being run into the hole. This pressure decrease would cause the borehole pressure to drop below that of the formation against which the pipe was stuck, reversing the pressure differential and freeing the pipe.

The drillstem test assembly was run mainly, however, as an experiment since, at the time, the theory of differential pressure sticking was not generally accepted in this area. Hole conditions above the fish were good and a packer seat was available just above the fish. These factors, plus the short time that the packer would be set and the ease of engagement and release of the pin type safety joint, minimized the danger of sticking the packer.

In one run with the drillstem test assembly, the fish was engaged, the hydraulic test tool was opened, the fish was freed and the pipe was pulled from the hole.

DST Fishing Assembly

The special DST fishing string (Fig. 2) consisted of the following components, from top to bottom:

Hydraulic jars to aid in release of the packer in case the attempt to free the pipe should fail.

Safety joint with lefthand release to free the drill pipe if the tools became stuck.

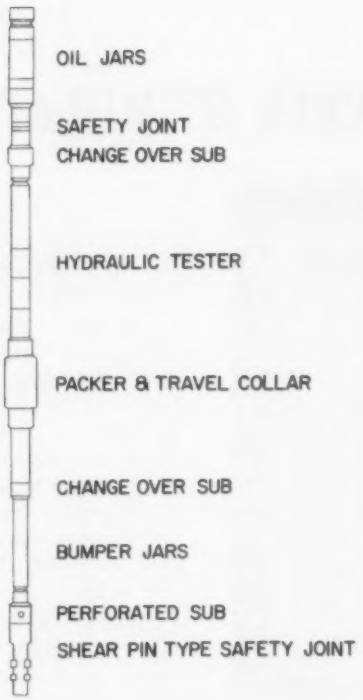


FIG. 2. **Drillstem tester fishing string** features use of hydraulic tester above a packer. When packer is seated above the stuck pipe, tester is opened, creating a pressure drop inside the bore hole which releases the stuck pipe.

Hydraulic test tool to control the flow of fluid from annulus to drill pipe with automatic shutoff if the fish came free. A disc valve was not included since no trouble in latching the pin type safety joint was anticipated. The quick opening action of a retaining valve might be more effective in some cases, but the strength of the valve plus the problem of equalizing below the packer would have to be considered.

Packer, 7½-in. OD conventional tool.

Bumper jars, with 30-in. travel, to facilitate release of packer without pulling on fish in case the fish remained stuck. Two sets of bumper jars might be more desirable.

Perforated sub, in lieu of perforated tailpipe, assuming that the fish was plugged.

Shear pin type safety joint (top half), to facilitate connection to fish. During fishing job, fish was caught and released at least six times with no difficulty using this type of joint. It would probably be worth an extra trip to install this joint in top of the fish before running test tool assembly. Plugging of fish between trips would probably be reduced if the joint was inverted, leaving pin up.

Discussion

This fishing job was apparently the result of an unquestionable case of differential pressure sticking. A free point indicator run after both washover runs showed that the top drill collar was stuck, even after the washover. However, tripping and unplugging fish required 12 to 16 hr in each case.

Other conditions indicative of this type sticking were noted. A comparatively high-solids gyp base mud was used to drill through a very porous zone indicated on the electric log between 7370 and 7600 ft. Wash pipe was run below this zone and light jarring with wash pipe in the hole failed to free the fish. Several zones of varying porosity are also found in the lime and dolomite section below the sand zone.

A questionable factor is the time element concerned with initial sticking of the drill collars. Although the kelly was backed out by hand, probably a mistake, drill pipe was stationary slightly less than four minutes while making connections. This seems to be a short time for differential sticking in a hole that had been exposed to hydrostatic pressure for at least 20 hr.

Application of the drillstem test tool fishing assembly instead of washover pipe might not be limited to cases of differential pressure sticking if the pipe is stuck off bottom. The sudden release of hydrostatic pressure in and around formation cavings or cuttings plus the severe downward shock at the top of the fish (estimated at 160,000 lb in this case) should be effective in releasing many stuck strings.

When off bottom, the fish can move down the instant it is released and can be "worked" immediately. Minor indications of this action have probably been noted before by field men running drillstem tests.

The drillstem test tool has been successful in at least three other fishing jobs in Montana and North Dakota. Continued success might result in development of a tool without the small bore and circulating problems of the standard hydraulic tool. Hole condition and packer seat remain major factors; however, a perfect packer seal may not be necessary in most cases. A hole condition which would permit use of large-OD wash pipe should be fairly suitable for a short drillstem test assembly.

* * *

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The art of

CABLE TOOL FISHING

ARTHUR O. AMES, *Acme Fishing Tool Company, Parkersburg, West Virginia*

In spite of improved cable tool drilling equipment, fishing jobs still occur. Here's a discussion of the most common jobs and their tools and methods

AN EXTENDED FISHING JOB can be the most expensive — and frustrating — part of an otherwise smooth-running drilling operation, whether in rotary drilling or cable tool drilling. But the proper use of tools and techniques has reduced most cable tool fishing to little more than bothersome routine.

The unique nature of cable tool drilling methods results in fishing problems which have required the development of tools and techniques peculiar to this drilling method. Some of these tools — such as fishing jars and spears — have been adapted successfully for use in rotary fishing operations.

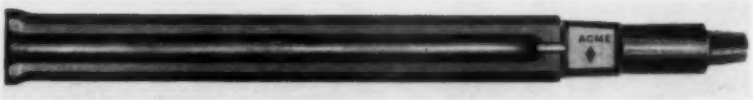
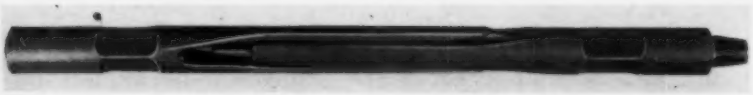


FIG. 1. Cable tool drilling bit.



Drilling jars.

Swivel socket.

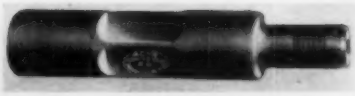


FIG. 2. Stiff rope socket (babcock).

FIG. 3. Fishing jars.

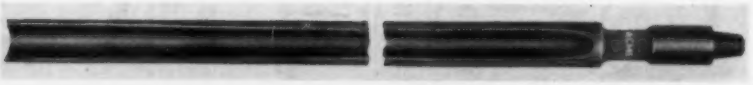


FIG. 4. Common spud.

FIG. 5. Solid forged friction socket.

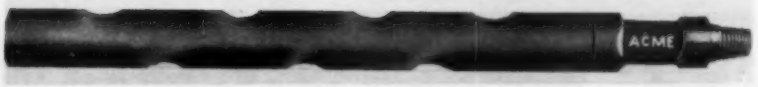


FIG. 6. Corrugated friction socket.

FIG. 7. Wireline center spear.

FIG. 8. 2-prong wireline grab.

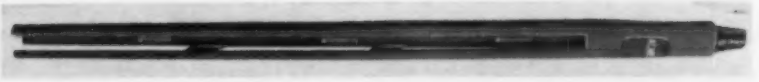


FIG. 9. 3-prong wireline grab.

Cable Tool Drilling String

Before discussing the problems of cable tool fishing, it might be well to take a look at the standard cable tool drilling string (Fig. 1). The string is topped with a rope socket into which the wire line fastens. Below the socket is a set of drilling jars which is used primarily for knocking loose a fresh bit if it should stick while running. The heavy drill stem below the jars provides the weight necessary to drive the bit when the tools are dropped. Finally, the drilling bit attaches to the end of the drill stem, completing the cable tool drilling string.

Cable Tool Fishing String

The fishing string of tools differs from the drilling string in the use of a stiff rope socket (Fig. 2), sometimes called a babcock, in place of the swivel type rope socket used in the drilling string. Also, jars used in fishing (Fig. 3) are longer in stroke than those used in drilling and are used below the stem to permit harder up-jarring.

Common Fishing Jobs

Lost bit. Probably the most common failure causing a cable tool fishing job occurs at the connection where the bit screws into the box of the drilling stem. If the pin of the bit breaks off, it is probably because the connection was made too tight, putting a destructive strain on the pin. If the box joint on the end of the stem breaks, it is usually the result of fatigue cracks in the box. Pin breakage on bits has been reduced greatly by the use of alloy steel in the manufacture of cable tool bits.

A failure of this kind leaves the bit in the hole. Prior to running a fishing tool to recover the bit, it is common practice to run a spud (Fig. 4) which is used to loosen the bit and straighten it in the hole so that the fishing tool can recover the bit without the necessity of excessive jarring.

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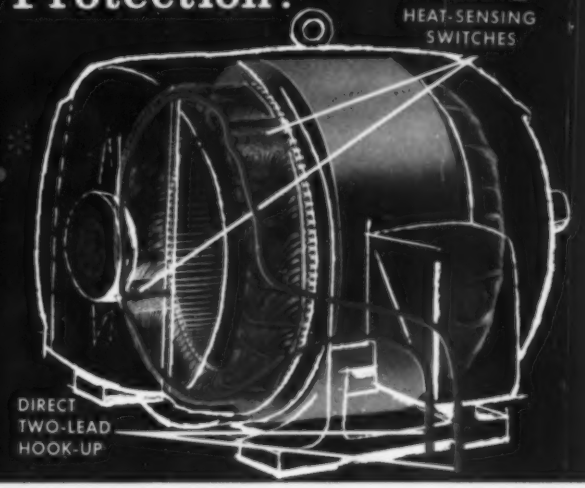

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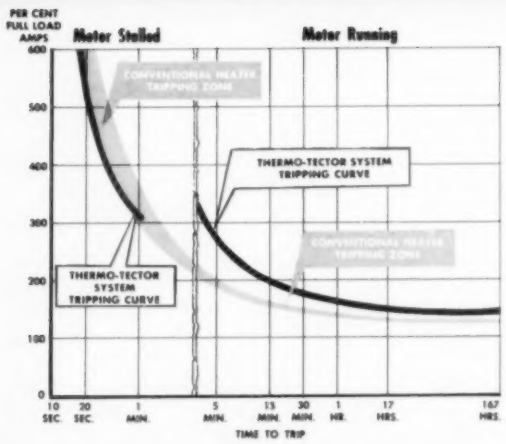

Performance curves show THERMO-TECTOR system's fast response to rapid heat rise (left) and greater motor output allowed under normal run conditions (right).

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After the bit has been loosened and straightened by the spud, the fishing string is made up with a friction socket, either the solid forged type (Fig. 5) or the corrugated type (Fig. 6). The friction socket is run down over the blade of the loosened bit, a friction hitch is secured, and the bit is removed from the hole.

Broken drill line. The next most frequent cause of cable tool fishing is the breaking of the drilling line in the hole during drilling operations. The incidence of this type of failure has been greatly reduced by improved drilling cables on the market today.

FIG. 10. Blind box.

FIG. 11. Drill mill.

FIG. 12. Combination socket.

FIG. 13. Latch jack.

Procedure for a fishing job of this kind is dictated by the amount of drilling cable left in the hole above the tools. In small holes, a wireline center spear (Fig. 7) is run on the fishing string to pick up the broken cable. In larger holes, wireline grabs are used, either the two-prong type (Fig. 8) or the three-prong type (Fig. 9).

Often when the line is picked up, either with a spear or grab, the lost drilling string will come out when the broken line is removed from the hole. However, if tools are stuck and the line is fished out down to the top of the tools, it is then desirable to run either a blind box (Fig. 10) or a drill mill (Fig. 11) to assure that the wire line is completely removed from the rope socket neck prior to running the combination socket (Fig. 12) which is made to take a hitch on the rope socket neck. The combination socket incorporates a set of internal slips which grip the top of the fish for removal.

Broken sand line. Occasionally, the sand line on which the bailer (Fig. 13) is run to remove cuttings from the hole will come loose from the bailer and will have to be fished out. This is accomplished by running a latch jack (Fig. 14) on the fishing string. If there is broken cable on top of the bailer, it can be removed with a center spear or a wireline latch grab.

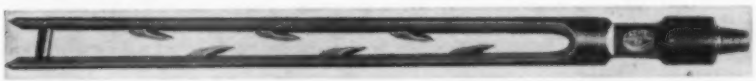

FIG. 14. Wireline latch grab.

FIG. 15. Devil's steel hand.

FIG. 16. Wireline cutting knife.

Small fish. Small loose objects, such as slips, sledge hammers, wrenches, etc., can be removed from the hole with a tool known as a devil's steel hand (Fig. 15).

Cutting drill line. Should the drilling string become stuck and cannot be jarred loose with the drilling jars in the drilling string, it may be necessary to cut the line at the top of the rope socket. This is accomplished by running a wireline cutting outfit (Fig. 16). The knife with cutters is run in over the drilling cable down to the top of the rope socket. The drilling line is cut at the top of the string by jarring up on the wireline cutting tool. After removing the cutting outfit and the drilling cable from the hole, a blind box is run to assure that the neck is cleaned of any loose ends of wire prior to running a combination socket to take a hitch on the rope socket.

Pulling casing. When necessary to remove a string of pipe or casing, the pipe may be found to be stuck at or near the bottom of the string. In this case, a trip casing spear (Fig. 17) is run in on the fishing string and a hitch is taken near the bottom of the pipe. The string of pipe is then jarred loose and removed from the hole.

Collar buster. If it is known that a couple of the bottom joints of casing are cemented in, the casing may be parted just above the cement, releasing the pipe above this point to be removed. This would be accomplished by running a collar buster (Fig. 18). This tool uses a heavy knife to cut a ribbon out of the threaded section of the pipe from just below the coupling into the collar. Removal of this strip of steel permits the pipe to collapse in the collar, and the pipe above the coupling can then be pulled from the hole.

Parted pipe. For fishing out pipe or casing that is parted in the well, the hollow casing spear (Fig. 19), releasing type, is run in on casing to take a hitch inside the parted pipe or casing.

FIG. 17. Trip casing spear.

FIG. 18. Collar buster.

FIG. 19. Hollow casing spear.

FIG. 20. Tubing connection tubing spear.

FIG. 21. Pin joint tubing spear.

FIG. 22. Wall hook.

The tool incorporates a set of slips which grip the inside of the parted pipe to pull the pipe from the hole.

Occasionally it is necessary to fish for parted tubing. For this, one of two types of tubing spears can be used; one type (Fig. 20) is made to run on tubing and the other (Fig. 21) is made with tool joints to run on tools on the bottom of a fishing string. Both of these tools incorporate two slips which take a bulldog-type hitch on the lost tubing. A stop ring on the tool limits the distance the spear enters the tubing and permits the removal of the spear at the surface without splitting or burning off the tubing.

Evaluation of Problem

These descriptions of the most common fishing jobs and equipment do not cover all cable tool fishing problems and techniques, but they do point up the relative simplicity of most such fishing jobs. Indeed, most fishing jobs are routine until they are complicated by poor judgment in running the wrong fishing tool because it happens to be handy rather than taking the time to send for the proper tool to handle the job.

The importance of proper evaluation of the problem and use of the correct fishing tool can be illustrated by a recent field experience. A contractor had completed drilling a well to approximately 4000 ft and was cleaning out in a shot hole below the 5½-in. casing prior to making a second shot. While in the hole, the wire line broke at the rope socket neck, permitting the top of the tools to fall over into the shot hole in such a position that it was impossible to get a fishing tool over the top of the lost tools.

The contractor made a proper evaluation of his problem and was advised to use a wall hook (Fig. 22) on his fishing string to hook around the lost drilling stem and straighten the tools in the hole. After the tools were standing straight in the hole, slack coal was poured down the hole to prop up the string while the wall hook was released from the fish and pulled from the hole. A conventional fishing tool then recovered the lost tools from the hole.

Improved drilling tools, wire line, and casing used in today's cable tool drilling operations have reduced the number of fishing jobs to a minimum and many of the jobs that do occur can be tracked back to negligence, poor practice, or running material that should have been replaced. However, in spite of all precautions, fishing jobs will still occur, but thanks to improved equipment and techniques, prolonged cable tool fishing jobs are very infrequent. ★ ★ ★

'riting and injuneers

MARY THOMPSON GARNER, *Tyler, Texas*

SOME PEOPLE THINK the cartoon of a grinning character in cap and gown, sheepskin in hand, observing "Just think — four years ago I couldn't even spell injuneer and now I are one" is a big joke.

But not me. I work for the injuneers.

And I assure you they can't spell a bit better than doctors and lawyers. When the doctors can't spell a word, they simply scribble more illegibly than ever. The lawyers just substitute another wherefore or whereas. The engineers use the slipstick method — they slip in a vowel here and stick in a consonant there. For some reason, they always add additional letters or syllables — they never shortchange a word.

But once they master a particular spelling, there's no backsliding. One engineer wrote a report in which he referred to millidarcies and millidarcys. Convinced that consistency had its merits, he decided to use the ys spelling throughout the report. So in a subsequent report he discussed discoverys, efficiencys, recoverys, permeabilitys, etc.

The word "personnel" always spelled trouble for another — and he always spelled it "personnell" — until he followed the suggestion to get literal-minded and remember that he had one "1" of a problem when dealing with personnel. He eliminated the spelling problem.

Engineers just couldn't make it if the word "approximately" disappeared from our language. They write that a well produced **approximately** 687.09 bbl of oil, that a particular job cost **approximately** $1,129.38, that a tract of land contains **approximately** 46.8365 acres, and that a certain interest is **approximately** 1.0000006672 percent.

They're also stuck on the phrase "it is indicated"; or "estimated"; or "believed." But never "it is," period. I guess you would call engineering an inexact science.

Most engineers are table-happy. Their reports are generously speckled with "as shown in Table so-and-so." They also like figures.

And then there are those who invariably claim engineering immunity when challenged on the grammatical structure of a report — allowing as how the questioned wording is "technical terminology." (It's usually a plain old dangling participle.)

Since the days of Theodore Roosevelt, the expression "rough and ready" has been associated with the adventurers and the fighters. Since the days of the typewriter, the expression "rough and double" has been associated with the engineers.

You might think of deadlines as applicable only to the writers who inhabit our fourth estate. Well, 'tain't so. Engineering journalists have them, too — and meet them in typical deadline-meeting style. A report with an 8:00 a.m. deadline is usually given to the typist at 4:45 p.m. the previous day.

Sometimes it's pert nigh impossible to secure approval for a workover on an engineer's report. Like all authors, they develop affection for their own little words. And sometimes it just doesn't seem worth the bother of having to explain again why "each of them were" ain't good English. Or why, other than it looks tadpoley, a sentence shouldn't be decorated with eight or ten commas. But then the engineers growl consent and something about grammar being for the birds — female, of course — and their fractured English gets splinted to the best of my ability one more time.

Their premise seems to be that two out of three isn't such a bad record — and they got readin' and 'rithmetic. Taught to the tune of a fast slipstick.

Jobs of a practically endless variety abound in the engineering field of the petroleum business world. My choice of them all? Why, report 'riting for the injuneers. Natcherally. ★ ★ ★

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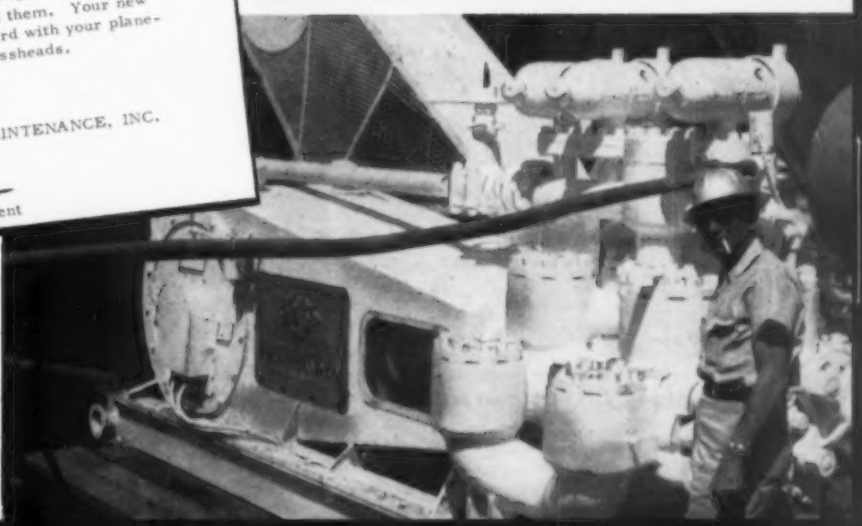

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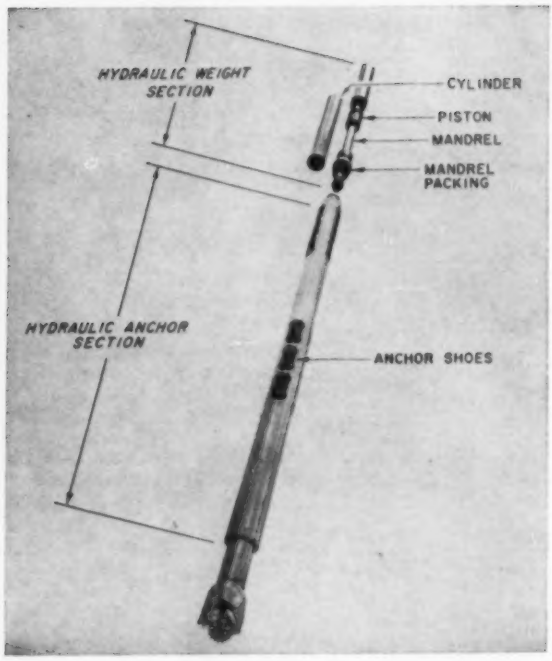

Jersey Production Research Company's new wall-anchored drill collar.

Brand-new downhole tool . . .

Jersey Research develops hydraulic wall-anchored collar

THE FIRST TOOL ever developed to provide heavy bit loading without using dead weight in the form of drill collars was revealed by J. M. Kellner and A. P. Roberts, project engineers for Jersey Production Research Company of Tulsa, Oklahoma, at 15th annual Petroleum Mechanical Engineering Conference of American Society of Mechanical Engineers at New Orleans recently.

Called the hydraulic wall-anchored drill collar by its developers, the new down-hole tool is a light-weight, high-output force applicator which makes it possible to apply high bit weights in hard formations near the surface, where conventional drill collars are limited.

Tool also reduces time required to break out a long string of drill collars, since only the one integral collar is run. Unique tool anchors itself to the walls of the hole to resist up-hole reaction, thereby making it a self-contained force applicator.

According to the developers, it has been used successfully in field wells in West Texas. Pressure drop across a jet bit applies pressure to three hydraulic cylinders which impose a load on the bit during drilling.

Prototype tool demonstrated operates in 6¾-in. hole. Its dimensions are 6-in. diam and 37-ft length. It weighs 2200 lb and during a 2-ft drilling stroke exerts about 40,000 lb at the bit, which is produced by a pressure drop across the bit of 1000 psi activating three hydraulic cylinders in series. Anchor shoe extends to engage borehole wall and can compensate for enlarged holes.

Anchor section of the tool contains 24 shoes placed at eight levels along the anchor sleeve, with each row of three shoes spaced 120 deg apart.

Mechanism of Tool

Hydraulic pushdown section. Inside three single-acting hydraulic cylinders placed in series, three pistons are attached to a hollow inner mandrel. This mandrel is attached at its upper end to the drill pipe and at its lower end to the bit.

A port in the mandrel supplies pressure to the upper side of the pistons, and a port in the cylinder vents the lower side of the piston to the annulus.

Rubber bearings support mandrel and pistons to reduce mandrel deflection, increase seal life, and decrease mandrel fatigue failures.

Anchor section. Anchor shoes, which are diaphragm-type pistons, absorb up-hole hydraulic reaction to hold tool in place and center it in the hole. An anchor sleeve attached to the lower end of the cylinder section holds the cores of these shoes, and a rubber insert bonded to each piece seals them in place. Tungsten carbide cylinders embedded in each core provide positive wall grip.

Hydraulic pressure enters through a port in the mandrel to operate shoes.

Retaining latch. When mandrel and pistons are pulled into the upper end of their stroke within the cylinder, a split-nut retaining latch locks them into place. During operation, the latch holds the outer case stationary as hydraulic pressure builds up in both pistons and anchor shoes until anchor shoes grip the hole wall sufficiently. Then driller rotates drill string to the right to release the latch.

How Tool Operates

Operation begins when driller runs the tool to the bottom with mandrel locked into upward position by retaining latch. After starting, circulation builds up from 400 to 700-psi pressure drop across the bit, which sets anchor shoes against the borehole wall.

Driller turns drill string to the right, which unlocks the retaining latch and increases the circulation rate to apply the necessary pressure to activate the tool and give the desired force to the bit. Then the drill string advances as drilling progresses for a length of the mandrel stroke.

At the end of the stroke, driller stops rotation of the drill string and reduces pressure drop across the bit to about 300 psi. This reduces pressure on the pistons but still keeps the anchor shoes stationary while driller raises drill stem to return mandrel to initial position. When mandrel reaches the top of its stroke, the latch locks the case to the inner mandrel.

When pump pressure reaches zero, the driller returns tool to the bottom of the hole and repeats the sequence.

Applying Bit Force

To use all bit force available, driller holds the drill pipe at its recorded weight while drilling. This places the neutral point of the drill string at the top of the hydraulic drill collar.

In using only a portion of the tool's output, however, the driller increases hook load above the weight of the drill string alone while drilling. ★ ★ ★

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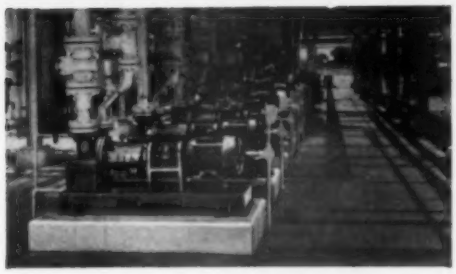
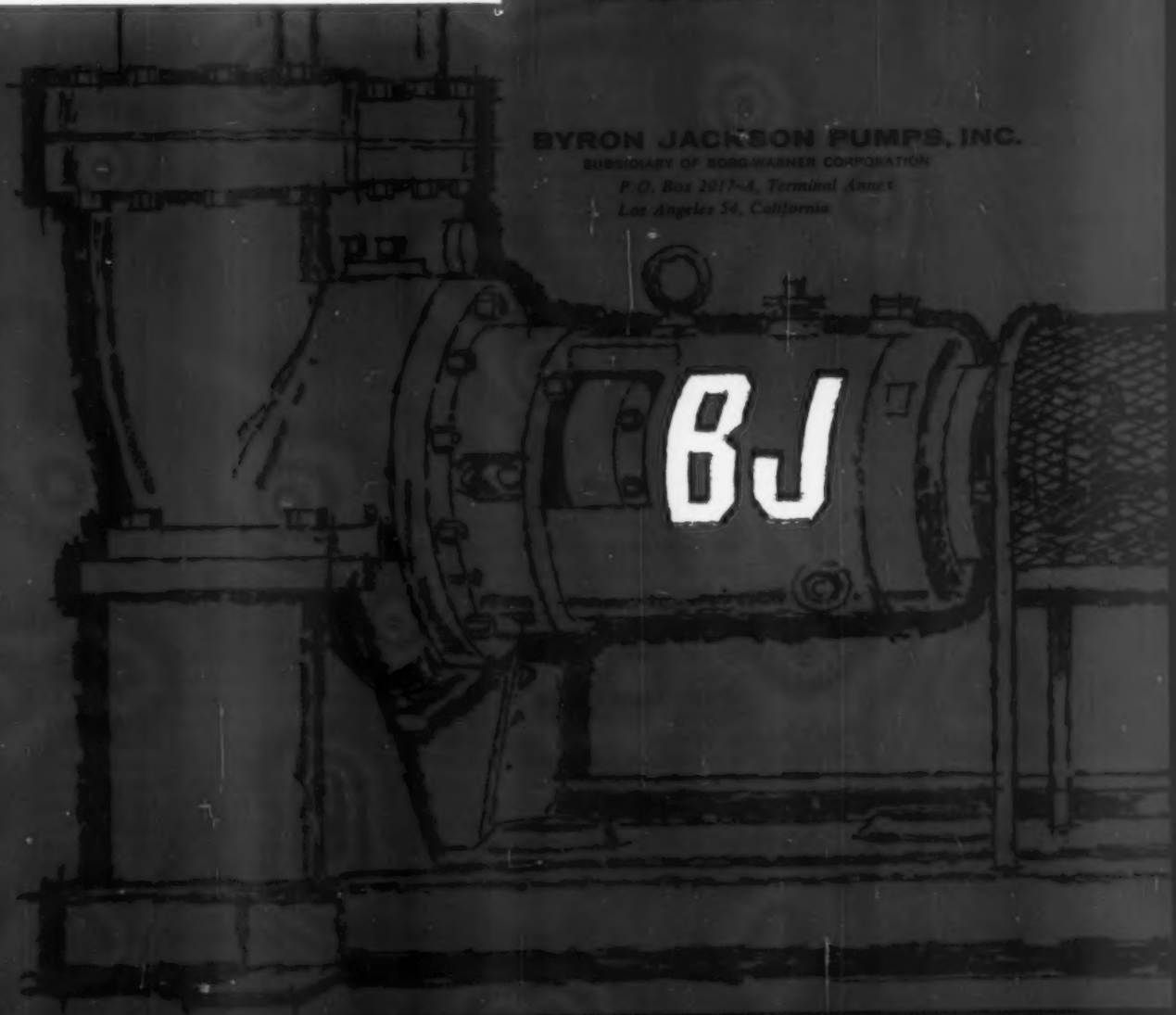


Continental Oil Company uses both SM and SMI model BJ Process Pumps in this Oklahoma field processing plant.

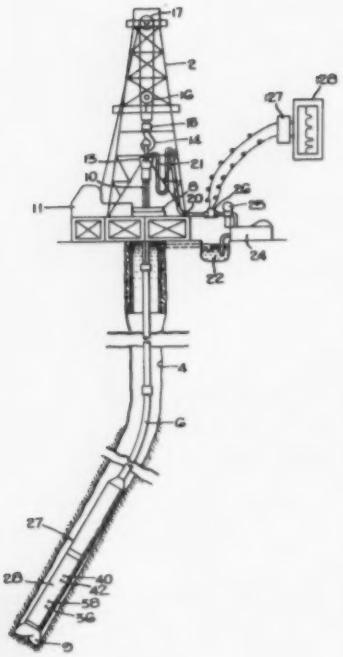
BYRON JACKSON PUMPS, INC.
SUBSIDIARY OF BORG-WARNER CORPORATION
P.O. Box 2017-A, Terminal Annex
Los Angeles 54, California



WHAT'S NEW IN PATENTS

Brief notes on selected drilling patents recently granted

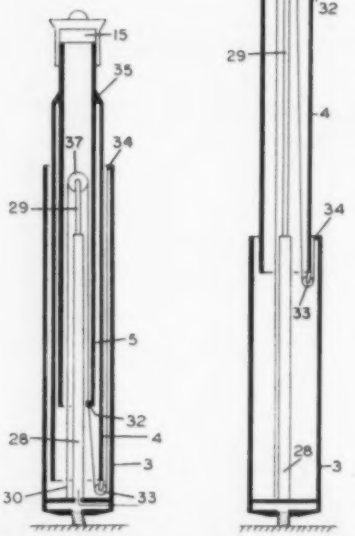
PAUL H. JOHNSON • JAMES R. HEAD
Patent Attorneys, Tulsa, Oklahoma



INSTRUMENT DETECTS AND INDICATES CROOKED HOLE

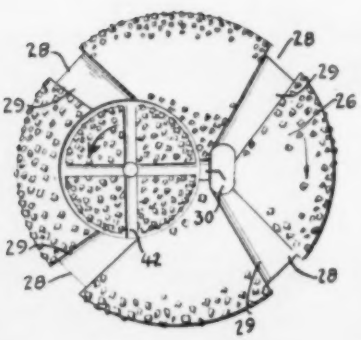
HOLE DEVIATION measurement and control have long been of major concern in drilling wells. An apparatus has been patented which is designed to detect and transmit to the surface during drill operations in deviation of the hole from vertical. One means of detecting this hole crookedness as suggested by the inventor incorporates stress gages attached to the drill pipe above the bit. As the drill pipe bends in crooked hole, the gages detect the strain in the pipe and transmit the information to the surface. The driller can then alter drilling rate, weight on the bit, etc. to correct for the crookedness without stopping the drilling operation. **Earth Borehole Crookedness Detection and Indication,** J. J. Arps, Patent No. 2,930,137.

TELESCOPING DERRICK POLES



PORTABLE DERRICK which is designed to be adaptable for mounting on a transportation vehicle consists essentially of a pair of derrick poles. Each pole is collapsible and extends by a system of cables and a hydraulic jack. Illustrations show one of the legs fully collapsed and fully extended. A crown block and crow's nest is installed between the upper end of the extended poles. **Portable Collapsible Derricks,** N. L. Emmons, Patent No. 2,920,725.

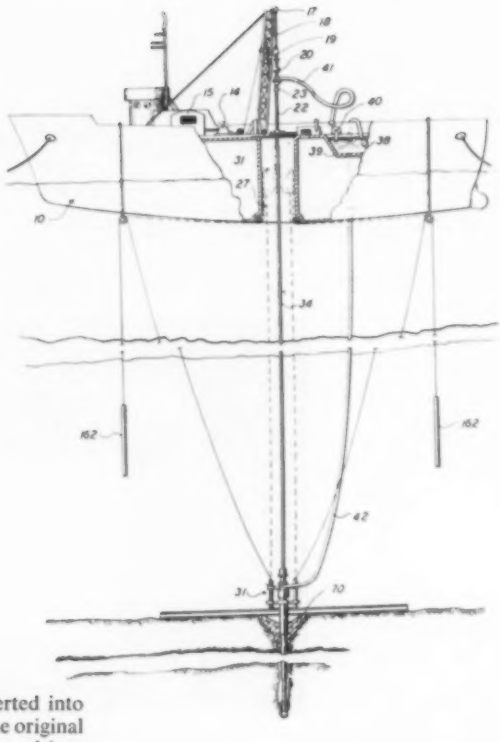
SMALL BIT ROTATES IN LARGER BIT

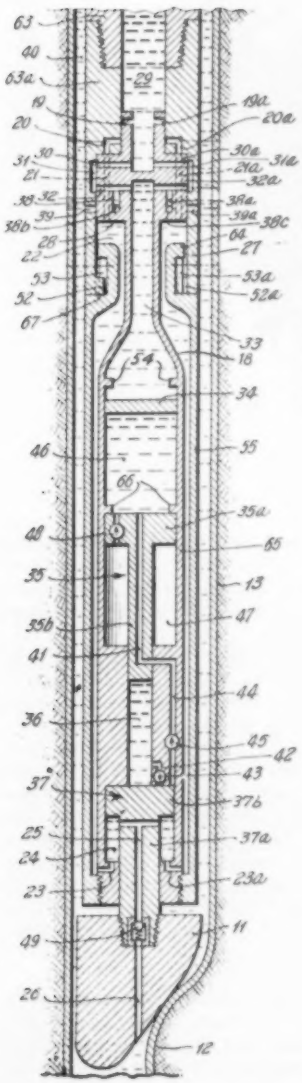


EXTRA "BITE" is the object of this drill bit design. A smaller diamond-surfaced bit rotates in a direction counter to that of a larger bit to which it is affixed. The small bit is supported by a shaft having a gear which engages a ring gear within the larger bit. An annular sleeve has star wheels to engage the side of the hole being drilled to hold the ring gear steady as the bit turns. The star wheels are arranged to rotate in a direction perpendicular to the rotation of the bit permitting easy movement up and down the hole. **Drill Bit with Driven Auxiliary Bit,** Eugene S. Wassel and Harry M. Cameron, Patent No. 2,877,988.

FACILITATES RUNNING CASING IN UNDERWATER WELLS

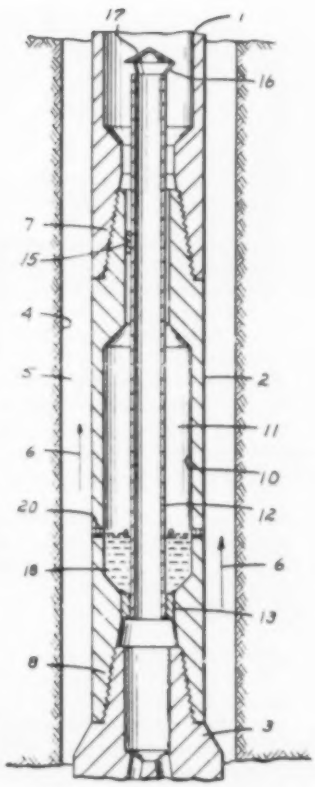
RUNNING CASING in deep water drilling is complicated by the necessity of stopping circulation of the drilling fluid, permitting solids to slough off the side of the drill hole and into the well. With this invention, the casing is suspended around the lower portion of the drill pipe as the hole is drilled and is carried into the borehole as drilling proceeds. When the hole is drilled to the required depth necessary to position the casing, the casing is released and the drill pipe is withdrawn. Throughout the setting process, the arrangement permits continued circulation of drilling fluids. **Drilling,** H. Stratton, Patent No. 2,929,610.





DOWNHOLE HAMMER STRAIGHTENS COLLAPSED CASING

POWER-DRIVEN SWAGE is inserted into collapsed pipe or casing to restore the original internal diameter. The swage is lowered into the collapsed casing on heavy tubing or drill pipe. Toothed slips grip the internal wall of the casing to hold the swage against the collapsed section. Fluid pumped down the pipe then hydraulically reciprocates the swage to hammer the collapsed pipe back to its original configuration. **Hydraulically Operable Reciprocating Motor Driven Swage for Restoring Collapsed Pipe,** W. B. Buck, Patent No. 2,877,822.



INJECTED WATER CONTROLS AIR DRILLING DUST

A SMALL QUANTITY of water injected into the air stream can help control dust at the surface from cuttings brought up in air drilling. But when water is introduced into the air stream and is pumped through the bit, the resulting "paste" formed with the cuttings interferes with efficient bit performance. This invention separates the water from the air before it enters the bit. Separator is placed directly above bit 3. A stand pipe 12 connects with the bit and extends into drill pipe 1. Air, carrying small amount of water, encounters canopy 17 placed over stand pipe 12, enters under canopy, and passes through stand pipe to bit. Water is separated at canopy and drains into cavity 11 and out through ejector ports 20 where it mixes with air coming back up the annulus to the surface, reducing dust problem. **Water Separator for Air Drilling,** George W. Baur and Henry B. Woods, Patent No. 2,920,872.

Cable tool drilling rig working in Appalachian Basin faces new competition from rotary rigs as producers look deeper for new production.

Cable tool drilling fights cost squeeze

Increased competition from rotary drilling in cable tool drilling country east of Mississippi spurs search for more economical cable tool drilling methods and equipment

BERMAN J. SHAFER, *Shafer Drilling Company, Wooster, Ohio*

CABLE TOOL DRILLING, the original means of drilling for oil and gas in the United States, is still in popular use in the Appalachian Basin where it was originally developed. But rising costs in all phases of cable tool drilling, combined with a trend to deeper exploration in the area, are making the rotary rig more competitive. Consequently, cable tool contractors are faced with the problem of cutting costs . . . or else.

There are approximately 1500 cable tool units operating east of the Mississippi River for the petroleum industry. There are several reasons for this majority of cable tool units:

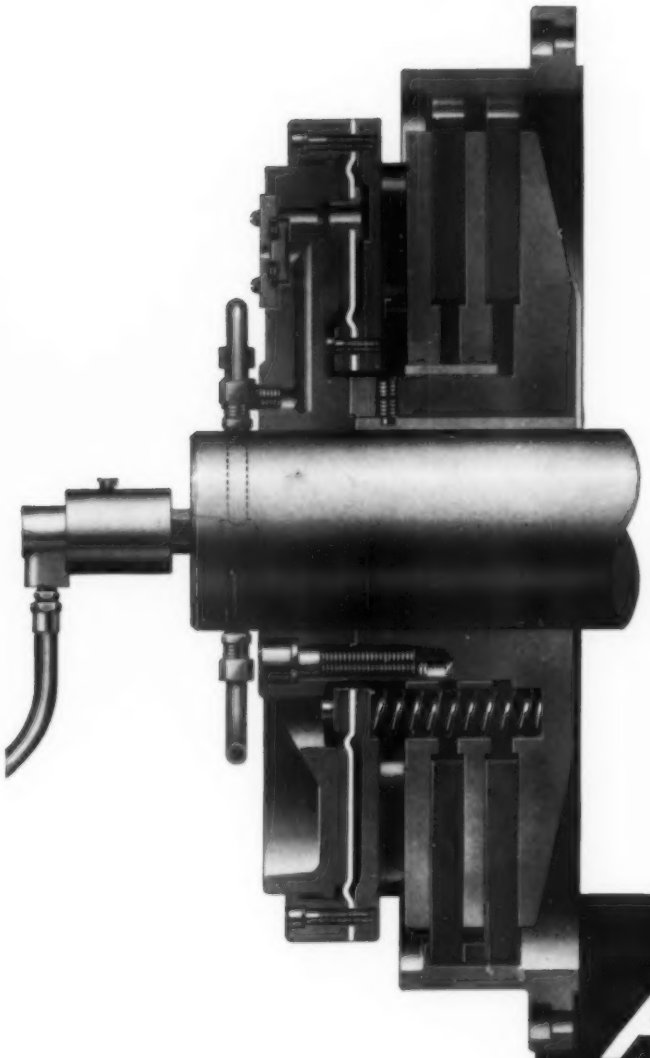
Low-pressure shallow pays. Operators in the Basin are accustomed to producing in low-pressure formations of which there are many found at varying depth. Penetration into these zones with a cable tool bit allows the operator to inspect visibly what production he encounters without danger of "mudding-off" a pay with a mud filter cake. The simplicity of making short runs into a possible pay section, pulling the drilling tools, bailing and testing, lends itself to eastern-type completions.

Relaxed schedules. Operators in the Appalachian area are not particularly concerned with the time element of completing wells within a certain time. Bank financing in the eastern areas for production is rarely found and independent operators do not find it a necessity to complete a well quickly.

Hard rotary drilling. Certain formations such as found in Ohio lend themselves to penetration by the cable tool method. As in the case of Ohio, a well projected to the Clinton Sand at a depth of 3300 ft will encounter approximately 2000 ft of shale and then approximately 1100 ft of limestone. This latter formation has been the bane of rotary contractors working in the state because of its hardness and attendant bit costs.

Lower cable tool investment. At the present time, rotary type drilling operations are more costly than cable tools. Although certain sizes of casing are eliminated in rotary operations, contracts are higher in costs. This of course is due to the fact that initial investment in rotary equipment is higher than cable tools. As in any other area, however, it is conceivable that more drilling experience, prudent operation, and the increased use of air as a drilling fluid will result in rotary drilling competing with cable tools.

Operators' cost-consciousness. Appalachian area operators have become quite cost conscious because the average productivity per well is less at present pro-



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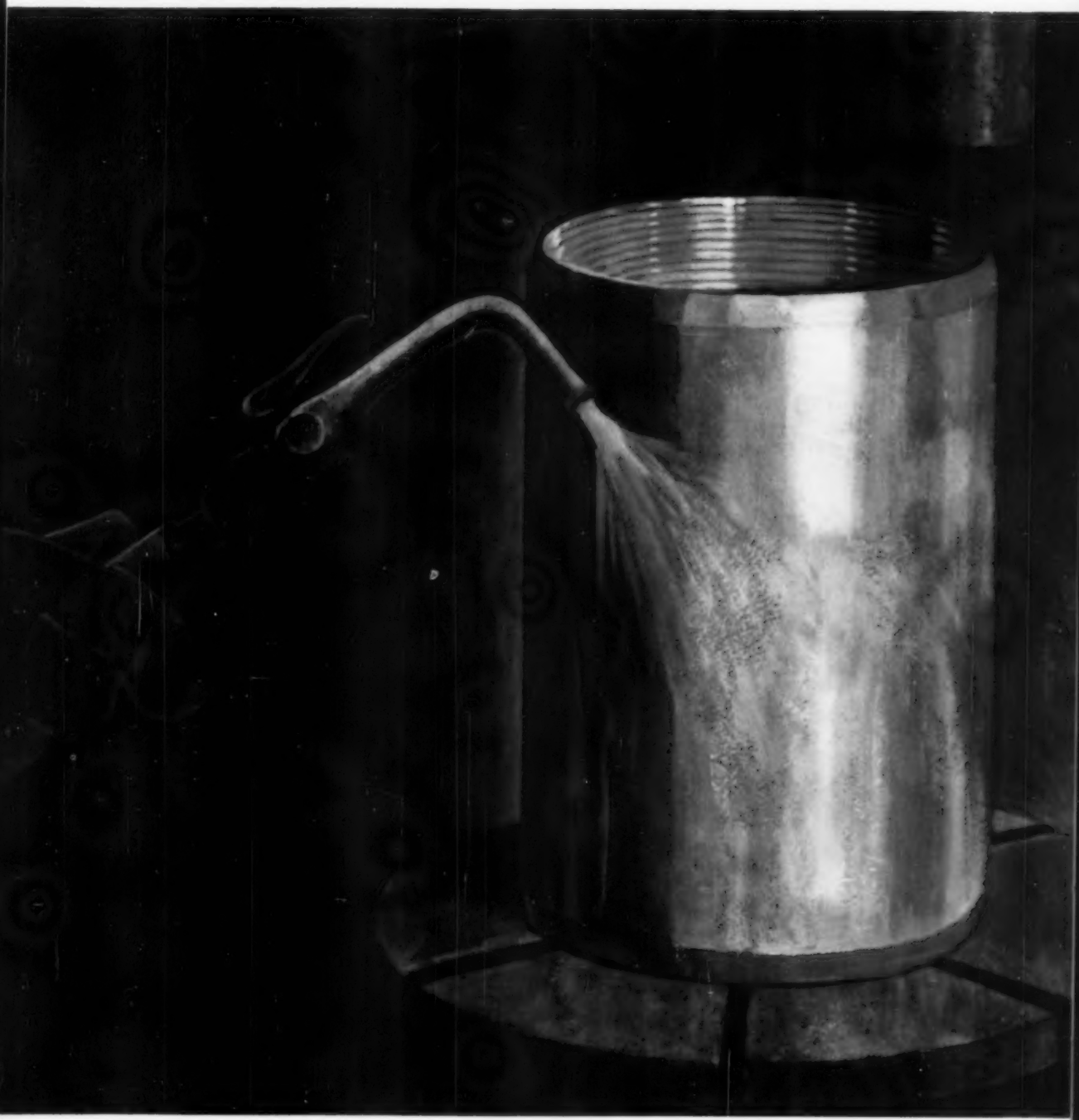

Look what's getting the 3rd degree

Illuminated by the weird glow of two powerful ultra-violet lamps, this casing coupling is sweating out a check for possible imperfections. It's a process known as Magnaglo inspection. Here a special-clearance coupling is being inspected.

The coupling is magnetized; then drenched with a reddish-brown solution that contains magnetic particles coated with fluorescent dye. If there is a surface defect on the coupling, fluorescent particles cling to it—held by the magnetic field which builds up around any imperfection in the steel.

The inspector then slowly rotates the coupling on a potter's wheel. He scans it carefully for any tell-tale

gleam that clearly indicates an imperfection.

Magnaglo inspection is only one of the many quality control methods used by National Tube during the production of USS National Seamless Oil Country Tubular Products. If you've got a tough oil country tubular problem, write National Tube Division, United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

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Heavy structural steel frame. Oversize brakes hydraulically equalized; adjusted in two minutes or less from operator's position. Forged brake flanges hardened and detachable. Main and sand line drums interchangeable. Full air clutches outboard-mounted for easy accessibility.

Check the many other features of the newest, most advanced servicing rig on the market. For complete details, write Bucyrus-Erie Company, Drill Division, South Milwaukee, Wisconsin.

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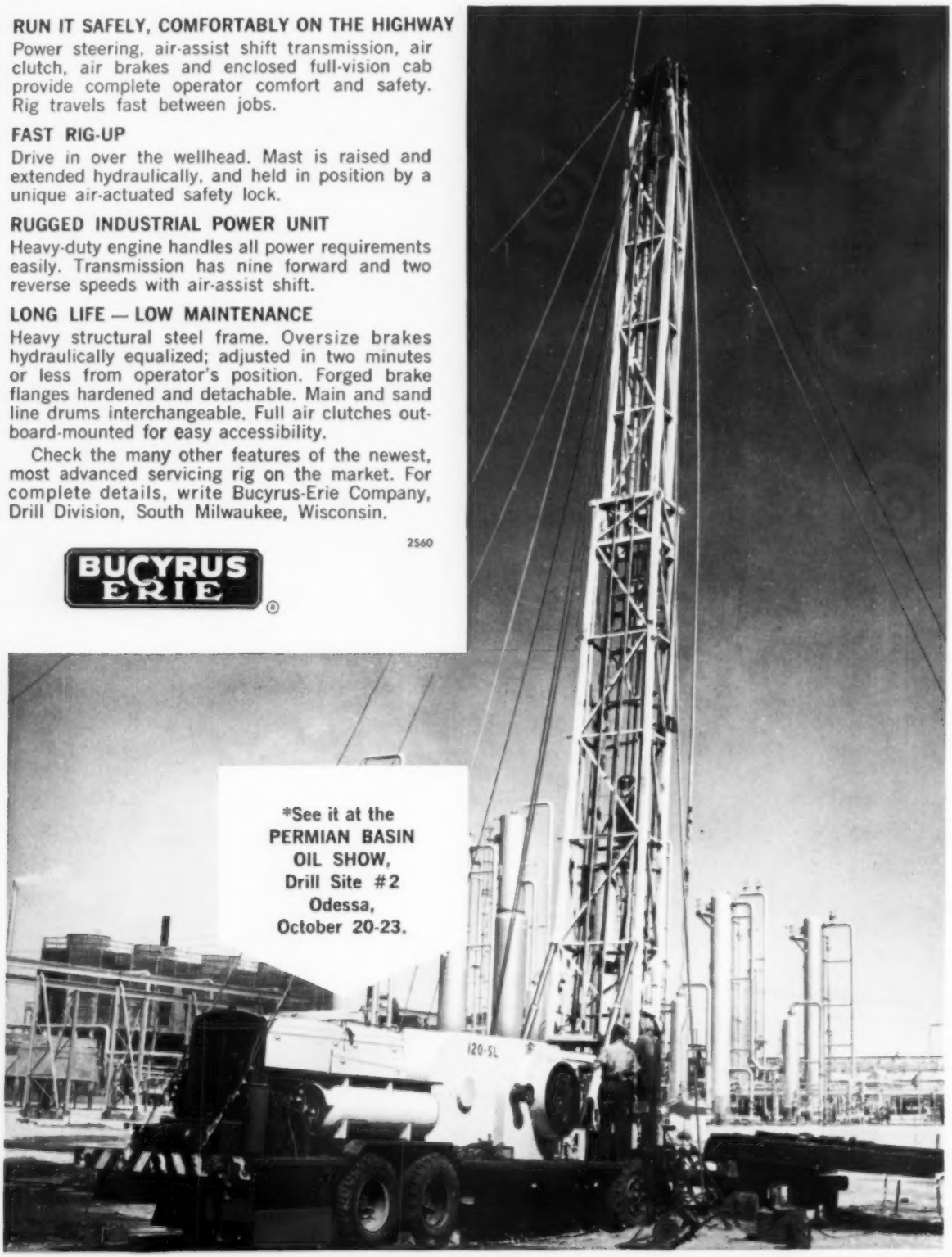
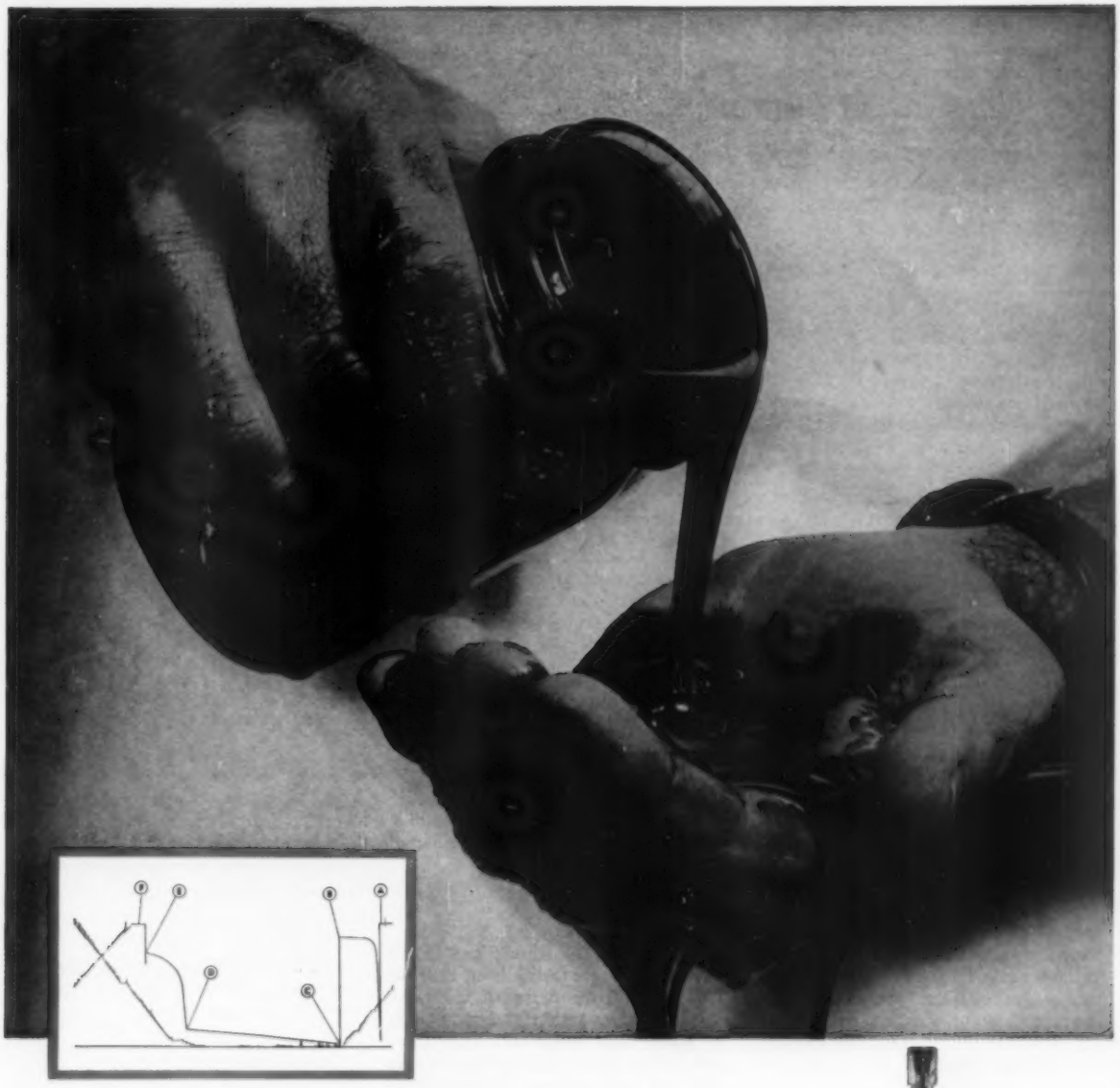


*See it at the
PERMIAN BASIN
OIL SHOW,
Drill Site #2
Odessa,
October 20-23.



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ducing levels than found in other areas and therefore there is a greater need for keeping costs down to achieve maximum profits.

Cable Tool Drilling Costs

In order to maintain footage costs as they are and therefore forestall any move by rotaries from entering the eastern areas in any great numbers, the cable tool contractor is faced with the problem of cutting his costs. The costs of equipment and supplies have increased far greater than footage contract figures. Since the contractor has little control over the costs of steel goods, he must look to other costs of operation for which he is directly responsible. These are (1) labor costs, (2) supervision (3) maintenance expense (4) fuel (5) cordage (6) overhead and administration (7) tool replacement and repair, (8) insurance and workmen's compensation.

Labor costs are contractor's principal expense item on a cable tool rig. The qualities of a good driller are not only the fact that he makes the most footage, but also that he is responsible for the best care of the rig. In cable tool operation, a driller and his tool dresser are needed for each tour. Some contractors will utilize 8-hr tours; others will have their crews work 12-hr shifts.

Maintenance expense involves the use of proper lubricants for bearings and other movable parts. It is also important that lubricants are kept free of dirt and grime before application. Grease packed in air-tight tubes for use in guns similar to caulking guns has remedied this situation. In calculating the waste involved the latter method is by far the cheapest.

Tool replacement and repair has become the most important expense item next to labor costs. A relatively recent development of alloy steels in drill bits, drilling jars, and stem joints have lengthened their life and lowered the rate of fishing jobs. A fishing job is caused either by drillers' neglect, faulty stem welds, joints, or a break in a drilling or sand line. There are various fishing tools manufactured to recover lost fish but in some cases special tools must be machined to do the job. Fishing jobs often can become a major expense in a driller's ledger of costs, but proper use of stem joints, care of wire cable, and proper drilling technique can avoid a majority of fishing jobs.

Cordage is also a major expense to a cable tool contractor inasmuch as the wire line is used for the drilling tools, the bailer, and the casing blocks. Failure to care for a wire line can assure the contractor of fishing jobs and a short line life. Undue bending, kinking, fatigue, localized wear are the principal reasons for poor wire performance. Proper instruction to the field men can correct these contributory troubles. Proper lubrication will curtail excessive corrosion due to exposure to salt water, corrosive gases, or an extended period of inactivity. Most manufacturers of drilling cable put into print the proper field care and use of wire rope, and it is important that this literature be read by all field men who handle wire cable.

Insurance. Most public liabilities polices as well as state industrial insurance is based upon annual payrolls. In Ohio the rate for drillers and tool dressers is above 4%. It is unfortunate that cable tool contractors have not carried out a campaign as found in the southwest areas of the United States where safety programs are emphasized as a very important phase of a drilling crew's work day. There are no enforced requirements for crew members to wear steel safety hats. Adequate protection from movable parts on the rig are not available from manufacturers. There is no wide use of the proper fire fighting equipment on and around the rig. A suitable safety program should be foremost in the mind of cable tool contractors to lower insurance rates.

Cable Tool Rigs

Aside from the direct costs mentioned above, there has been little accomplished over the past few years in the modernization and remodeling of cable tool equipment. The largest spudder manufacturers serving the eastern area have utilized the same styles and models for years. It would appear that there would be a greater demand for cable tool equipment if the manufacturer would have a representative spend a period of time interviewing contractors to determine their needs and contributions to the design of a drilling machine suited to the field man.

As an example, none of the spudder manufacturers maintains a staff of trained mechanics to call in the event of equipment breakdown. As a result, the driller, the toolpusher, or a local mechanic must be able to repair any equipment that fails. In many cases, the equipment is so constructed that parts are difficult to replace with the usual collection of tools. Consequently, a great deal of time is consumed in diagnosing the source of the trouble, as well as the time spent in repairing the trouble.

The most popular spudder model does not have grease seals located at working parts at the top of the mast, but instead it has bushings which must be lubricated with a grease gun. Inasmuch as these parts are working on a 24-hr day basis, they must be lubricated accordingly. This constitutes a safety hazard, for the employee must operate lubrication equipment 50 ft above ground level.

All models should have as standard equipment a sturdier mast capable of handling casing loads far greater than presently allowed in their specifications for a particular depth. Instead of a double-pole mast or a steel channel type mast, it would be advisable to have a tripod type split derrick.

Experience has shown that the storage capacity of the bull reel and sand reel drums is not in line with the capacity of the machine. Dividers must be changed from one well to the other of similar depth to accommodate sufficient drilling line for the working side of the reel. The result of this has been to compact all reels into a box frame allowing little or no provision for repair in the field in the event of a part failure.

It is further noted that various weaknesses occurring in similar models over the past ten years have not been corrected in new models being manufactured. Although it is possible to order equipment special for each contractor's needs, it must also be remembered that such units are prohibitive in cost. Therefore, it would appear that manufacturers should consult contractors in various parts of the country to ascertain the constructive criticisms which are evident.

Conclusion

It is the general consensus of cable tool contractors drilling to the Clinton Sand in Ohio, that a 3000 ft well should be completed in thirty 24-hr days or less. A rotary contractor in Ohio has completed wells to a similar depth in 6 days. There have been cases where cable tools have completed wells in as short a time as 15 days. But as mentioned before, the time element has not been important in Ohio thus far. However, a trend to sink deeper tests to 6000 ft and more has shown a change from cable to rotary. Although these tests have been few to date, it is logical that more experience in drilling to these depths will pave the way for more rotary contractors. With this added competition, the successful cable tool contractor will be the one who has found the way to lower his costs. ★ ★

Macks are the muscles of the oil fields. Here one of Hilderbrandt's B-75 Model Macks loads up for a rugged off-highway run to a remote drilling site. Roadless terrain is taken in stride because Mack oil field trucks are built for oil field work.

MACK
for over 7 straight years
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Help smooth drilling operations

Breakdowns or tie-ups have no place in the round-the-clock trucking operations of Hilderbrandt Tank Service, Inc., Lindsay, Oklahoma. On 24-hour call, their vacuum tank trucks must roll on a moment's notice with pressurized loads of drilling mud, frac-oil and other compounds used to smooth the kinks out of oil drilling operations.

Says President Floyd Hilderbrandt, "Oil-field service offers some of the worst off-highway truck operating conditions. We use Macks on these rugged jobs because they outperform any of the other units we operate, give us good economy and work with an absolute minimum of downtime."

When your vehicles must tackle unusually demanding terrain conditions, Macks will perform where other trucks bog down—in mud, loose gravel and sand—thanks to Mack's exclusive Balanced Bogie with Power Divider. It's a four-wheel drive, tandem rear-axle assembly with an inter-axle differential that directs the most power to the wheels having greater traction. The Power Divider allows for differences in speed between wheels, maintains traction in slippery going and preserves true differential action without surging or vibration. Mack-built Thermodyne® engines—gasoline or diesel—are unexcelled for long life, dependability and fuel economy. Mack-built transmissions—available up to 20 speeds—are built to accommodate a variety of power takeoff units.

In oil field service—as in any operation where more is demanded of a truck—you'll get more out of a Mack. Your Mack branch or distributor will be glad to show you why. Mack Trucks, Inc., Plainfield, New Jersey. Mack Trucks of Canada, Ltd., Toronto, Ontario.

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automated drilling rig

AN AUTOMATED DRILLING RIG is the subject of a fascinating article appearing in the August 26, 1960, issue of *The Petroleum Times*, published in London. The article, authored by H. D. Fanshawe, F.N.R.D., Ltd., is not a work of science-fiction, but is rather a sound report on the actual development of a well-engineered and practical drilling machine.

Several unique features of the all-hydraulic deep hole rig are evident at first glance: it has no drawworks, blocks, or rotary table; pipe pulled in singles is racked horizontally by automatic transfer arms and the string is rotated by a hydraulically powered swivel; the power house, probably trailer-mounted, is connected to the rig and to pressure-exchange diaphragm slush pumps by fluid lines only; twin hydraulic lifts pull drillpipe automatically and continuously while breaking out singles without stopping.

For Deep Drilling

A current study in the U. S. will develop details of the rig's economic performance, but it is already clear that the new rig can compete with conventional rotary rigs only in drilling below 5000 ft. Developers estimate that overall cost savings in deep drilling will amount to more than 15%.

Pulls Pipe 'Non-Stop'

Probably the most radical innovation in the hydraulic rig is in the hoisting system. Two hydraulic lifts, one above the other, travel in opposite directions in a reciprocating cycle. Pipe is gripped by the lower lift at the bottom of its stroke and is raised to the top of the lower-lift stroke where it is then gripped by the upper lift which is at the bottom of its stroke. As the upper lift continues to raise the pipe to the top of its stroke, the lower lift returns to the bottom to grip the pipe and complete the cycle.

The upper lift carries a make-and-break unit which breaks out the upper single, removes it from the string, and passes it to a transfer arm which automatically places the single in a horizontal rack. The entire pulling and break-out procedure is performed without stop and with the pipe coming out of the hole at a constant speed of 240 ft per min.

Drilling

Without a rotary table, the rig uses a hydraulically-powered swivel to rotate the drill pipe. The swivel is mounted on the upper lift and drills to the bottom of the upper-lift stroke, where it then transfers itself to the bottom lift to complete a drilling stroke.

Slush Pumps

The mud system contains a pressure-exchange diaphragm pumping unit instead of conventional piston pumps. A chamber is divided by a flexible diaphragm into two sections. Oil from the hydraulic power source is valved into one section and forces the mud out of the other section.

Further Development

So far, development of the rig has been sponsored by the National Research & Development Corporation with the aid of government grants. But further government assistance will be limited by the relatively small benefit that British industry would enjoy from the perfected rig. In fact, the future of the rig in the United Kingdom must depend upon support from the oil companies since development costs of a project of this scope are beyond the resources of independent British equipment manufacturers.

IT BEGINS HERE!..

Here, in this modern, spacious plant in Butler, Pennsylvania, is where the enviable Spang reputation begins—a reputation known everywhere and wherever cable system drilling and fishing tools are used.

Here men with cable tool savvy constantly strive to improve tool design, to upgrade metals, to speed up manufacturing processes. All this with an eye to making a good drilling or fishing tool BETTER!

True, the reputation that begins here reaches out to every cable tool rig using Spang tools . . . making a good drilling operation BETTER!

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For over 60 years manufacturers of BETTER Cable System Tools for Oil, Gas and Water Well Completion.

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The benefits of a good mud program, a *planned* Magcobar mud program, are reflected in total drilling cost. These benefits can extend even to better and more production without the use of stimulants.

On your next well, reduce hole time, speed up drilling, stabilize the hole, and reduce wear and tear on drilling equipment. You'll be in good company, too, right along with the 92 per cent of the world's oil companies who use Magcobar now. And you'll be helping yourself with the better-engineered mud products of Magcobar.

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DRILLING MUD SERVICE

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MAGNET COVE BARIUM CORPORATION
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Well Done With Magcobar Technology

EXPLORATION ACTIVITIES

GUATEMALA

El Peten Group Operator Approved By Government

Guatemalan government has approved Delhi Guatemala Exploration Corporation, subsidiary of Delhi-Taylor Oil Corporation, as operator for El Peten group which is conducting exploratory activity in Northwestern Guatemala.

Group, composed of Delhi Guatemala, Guatemalan Atlantic Corporation, Guatemalan Sun Company and Pure Oil Company of Guatemala, has concessions in two areas comprising about 1,337,000 acres. Only geological and geophysical operations have been conducted thus far.

Oil Shows Discovered From Two Limestone Zones

Oil shows have been discovered in a well being drilled in Guatemala by Continental Oil Company and its associates. Wildcat was spudded about 18 miles north of Chinaja No. 1, first exploratory test drilled by operator.

Newest exploratory well, known as Ohio San Roman No. 1, tested oil shows from two zones of thin limestone at 8000 and 9000 ft. While not indicative of commercial production, recovery of sweet crude oil lends encouragement on well, which is below 9100 ft on projected test of 13,000 ft.

Conoco owns 33⅓ % of the venture.

GEORGIA

Wildcat Location Staked, May Capture Cash Award

Humble Oil & Refining Company has staked location for a new attempt to find commercial oil production in Georgia. Wildcat will be drilled seven miles north of Gardi, in Wayne County.

State of Georgia has offered $250,000 to company that opens commercial production in state.

TURKEY

Well Now Largest Producer As Flow Rises To 1200 Bpd

Mobil International Oil Company said indicated yield of an exploratory well near Mersin, Turkey, has reached 1200 bbl per day. Well was announced last month at 240 bbl per day.

After treatment, the well, Bulgurdag 1, flowed 38.9 gravity low sulfur crude without water through a ⅜-in. opening. Test confirmed it as largest oil strike in Turkey.

Mobil holds exploration licenses on almost 1 million acres in Adana Basin, where strike occurred. Several other wells are scheduled for this year in same concession area to determine extent of oil reserve tapped by Bulgurdag 1, and to probe other structures in vicinity.

PHILIPPINES

Eleven Operators Drill 24 Wells as Pace Quickens

Little has been publicized about the stepped-up activity in the Philippine Islands. But, without much fan-fare, some eleven operators have been plugging away in an oil and gas search that increases by the month. So far in 1960, 24 wells have been drilled, bringing the islands to an estimated 107 wells drilled. Major U. S. affiliates active include Stanvac, White Eagle, Caltex, American Asiatic and Philadelphia Oil Development Company.

While no major discoveries have yet been found, several encouraging shows and potential petroleum source formations spur-on activity.

CALIFORNIA

Wildcat Well Underway In Stanislaus County

Occidental Petroleum has acquired about 5000 acres in Sacramento Valley of northern California and has commenced drilling a wildcat well.

Firm's new acreage is in Salida area of Stanislaus County, about three miles northeast of Vernalis gas field and five miles southeast of recently-discovered McMullin Ranch gas field. Actual location is Section 16, Township 3 South, Range 7 East.

Test well will be drilled to a depth of about 7000 ft and will probe Blewett and Tracy sands, both currently productive at Vernalis and McMullin.

VENEZUELA

Thickest Sand Discovered Flows 7500 Bpd

Venezuelan Sun Oil Company has completed a significant oil well in Lake Maracaibo, Venezuela.

Drilled on Block 1 concession, well encountered 1797 ft of productive oil sand which, according to Venezuelan Ministry of Mines and Hydrocarbons, is thickest oil sand ever discovered in Venezuela.

On initial production test, well produced 7500 bbl per day of 30 gravity crude oil through a ¾-in. choke.

Well was drilled on Block 1 concession held by Venezuelan Sun, Venezuelan Atlantic Refining Company, and Texaco-Seaboard, Inc.

NEW MEXICO

Wolfcamp Zone Discovery Flows 1224 Bpd

Union Oil Company of California has opened a new Wolfcamp zone oil field in Lea County, New Mexico, at its No. 1-33 Union-State, in NW of 33-15s-32e, 7 miles northeast of Maljamar and 5 miles west of South Saunders Field.

Wildcat was drilled to 13,502 ft and casing perforated at 9952 to 9980 ft; on completion test well flowed 1224 bbl of oil a day, with gas-oil ratio of 1550-to-1 on a 30-64-in. choke.

Devonian Oil Strike Tests 269 bbl in Lea County

A Lea County venture was finaled as a Devonian oil discovery and on a 20-hr potential test, well flowed 269-bbl of 40.6 gravity oil through an 11/64-in. choke in perforations between 9865 and 9910 ft after an acid treatment of 1500 gal.

Flowing tubing pressure was 1400 lb.

Total depth is 12,950 ft with 5½-in. casing set at 12,948 ft. Plug-back depth is 9916 ft.

Wildcat Tapping Abo Reef Indicates 2350 Bpd On Test

Previously-reported wildcat which taps Abo Reef in Loco Hills field for first time has indicated a potential of 2,350 bbl of crude per day on latest in series of drillstem tests.

U.S.A.-Woodley No. 1, a joint discovery by Texas Pacific Coal & Oil Company and Ambassador Oil Company in northeast Eddy County, flowed at rate of 98 bbl per hr from between 6666 and 6846 ft in Abo Reef formation.

ENGLAND

Exploratory Drilling Yields 5 Completions on Mainland

BP Exploration continues exploratory drilling activities both in Midlands area and elsewhere in England.

Two wells at Apleyhead and South Leverton, Nottinghamshire, have recently been completed, and tests of some lower coal measures sands revealed encouraging indications of oil. These suggest the possibility of yet two more small fields in this region, although further testing will be necessary.

Three 2000-ft holes have recently been completed at Kimmeridge, Dorset.

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148

LIBYA

Third Largest Well Completed In Area Flows 11,500 Bpd

Third largest well ever completed in Libya, F-9 well in Concession 32, flow-tested at rate of 11,500 bbl per day. Flowing 40 deg gravity crude, well extends Dahra field two and one-quarter miles southeast from F-2 well, which has tested at rate of 8000 bbl per day. Crude from new well flowed through perforations from 3066 to 3106 ft and 3120 to 3130 ft.

Oasis Oil partnership, composed of The Ohio Oil Company, Amerada Petroleum Corporation, and Continental Oil Company owns both F-9 and F-2.

KENYA

Stratigraphic Holes Begun In Lamu Area of Kenya

BP-Shell Petroleum Development Company of Kenya has begun drilling series of medium-depth stratigraphic holes in Lamu area of Kenya.

Wells are intended to provide geological information to supplement seismic work being carried out in area.

First well is expected to spud-in next week at location on Tana River, about 30 miles south of Bura. Portable rig, capable of drilling to 6000 ft, was brought in to drill wells.

COLOMBIA

Promising Wildcat Well Has 4000 Bpd Potential

Promising discovery is Sinclair Oil & Gas farmout from International Petroleum Company, Ltd., Santos 1 wildcat which was drilled to 9960 ft. It is under test and unconfirmed reports announce that it has some 350 ft new pay which could yield 4000 bbl per day of 37 deg API oil.

Two rigs will be moved in for developing pool.

TEXAS

Offshore Wildcat Location Staked 31 Miles Into Gulf

Shell Oil Company has staked location for an offshore wildcat 31 miles south of Galveston in Gulf of Mexico.

Test will be drilled on a 5760-acre tract, Federal Block OCS-288, in about 65 ft of water.

Drilling operations will utilize a mobile drilling rig in drilling to a projected depth of about 10,000 ft.

Well will be second farthest drilled off Texas coast. In 1956, Shell and Continental Oil Company jointly drilled two wells about 63 miles off Galveston in 80 and 90-ft water depths.

Designated as Buccaneer area, wildcat is first test of Shell's 126,720 acres obtained for $23 million at Federal lease sale in February, 1960. Company currently holds leases on a total of 134,482 acres off coast of Texas, with 7762 acres lying in state zone and remainder in Federal zone farther from shore.

Wildcat Flows 5.6 MMcfd Of Gas in Matagorda County

Lion Oil Company division of Monsanto Chemical Company announces a successful wildcat discovery well on a 1600-acre tract southeast of El Maton in Matagorda County, Texas. Buckeye No. 1 was completed as a gas-condensate well in Lower Frio sand at a depth of 10,550 ft.

On initial test with ¼-in. choke, well flowed 5,650,000 cu ft of gas and 330 bbl of condensate per day. Monsanto has leases on an additional 3500 acres in area of this well.

Prolific Gas-Distillate Discovery Flows Two Zones

Kewanee Oil Company reported completion of a prolific gas-distillate discovery well which will produce from two pay zones, Fusselman and Ellenburger, in West Texas.

Well, No. 1 Stiles, is in central Reagan County, 10 miles north of Big Lake, Texas, 70 miles southeast of Midland and 3½ miles southwest of nearest Fusselman and Ellenburger production in Stiles area.

From Fusselman, discovery had a calculated absolute open flow of 22,000,000 cu ft of gas daily, with a petroleum potential of 952.35 bbl of 58.6 gravity distillate.

That production is from perforated sections at 10,373 to 10,382 ft.

From Ellenburger, well had a calculated open flow of 4,300,000 cu ft of gas daily with a daily potential of 349.59 bbl of 58.3 gravity distillate. Production is in open hole at 10,441 to 10,557 ft.

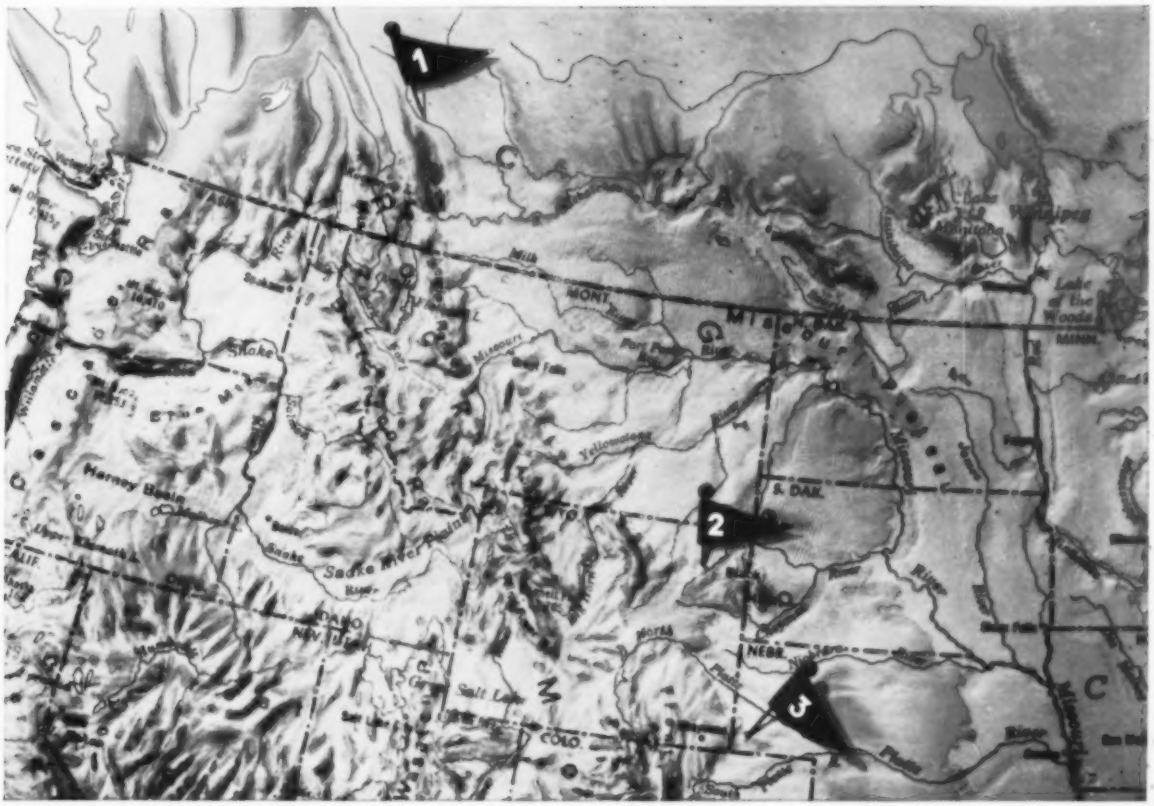
Gas Well in Lopena Field Flows 3 MMcfd at 3720 psi

Major confirmatory step-out gas well in northeast Lopena field in Zapata County, Texas has been announced.

Well, Juan Benavides No. 2, was completed in lower Wilcox formation through perforations at 10,082 to 10,090 and 10,124 to 10,144 ft. On test, well produced at rate of 3 MMcfd through a 3/16-in. choke with 3720 psi tubing pressure. Shut-in pressure was 7000 psi.

Construction of a gathering system for area will begin shortly, with completion expected by end of this year.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD



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Hagan Controlled Solubility Phosphates Solved These Scale Problems

Most of the oil field water in the Rocky Mountains is relatively fresh and has a strong tendency to form calcium carbonate scale. Here are three areas where Hagan Controlled Solubility Phosphate solved this problem:

1 *The Pembina Field of Alberta*, where 50°F water from shallow aquifers is pumped into the Cardium sand at 130°F. Stable at lower temperatures, the water deposits calcium carbonate as it warms up near the sand face in the injection well. Scale can build up so fast that injection pressures increase from 300 psi to over 1500 psi in 30 days.

In one section this scale problem was severe. There were forty input wells—each with its own water supply well and high pressure pump. A central treating system was not feasible. But the unique "automatic proportioning" property of Hagan's 15-J Controlled Solubility Phosphate let the operator have the equivalent of forty separate treating plants for less than the cost of a pump.

Bypass feeders were installed at all supply wells and charged with enough 15-J to maintain a continuous 6 ppm feed rate. Once each month, a small booster charge of 15-J was added to keep treatment at an effective level. Injection pressures went back to normal. Total cost for the first year of treatment was less than 2 mills per bbl. of water injected.

2 *In Wyoming's Donkey Creek Field*, a produced water which had only a slight tendency to form scale in the producing wells became a real trouble maker when the water passed through the treaters. Heavy deposits of scale formed on the fire tubes and caused failure—sometimes in less than three months.

Producing wells with a known scaling history were selected for standard downhole treatment with 15-J. Dosage was regulated by monitoring the amount of phosphate in the water at the dump valve of the treater. After six months it was evident that adding a charge of 15-J to the producing wells once each week was enough to prevent scale from forming all the way through the system. A real double benefit treatment—and for a total cost of less than 3 mills per bbl. of water produced.

3 *Kimball, Nebraska*. Here calcium carbonate scale forms in the producing wells so fast that operators in the area have but two choices—preventive treatment—or—go out of business.

Since bottom hole temperatures are extremely high and the upper or "D" sand causes most of the trouble, bypass feeders at the well head are used. A small amount of produced fluid is continuously passed through a bed of 15-J and back down the annulus. Scale is stopped before it starts. One of the early users of 15-J in this area says that since starting treatment two years ago, his workover costs have been reduced 50%.

HAGAN
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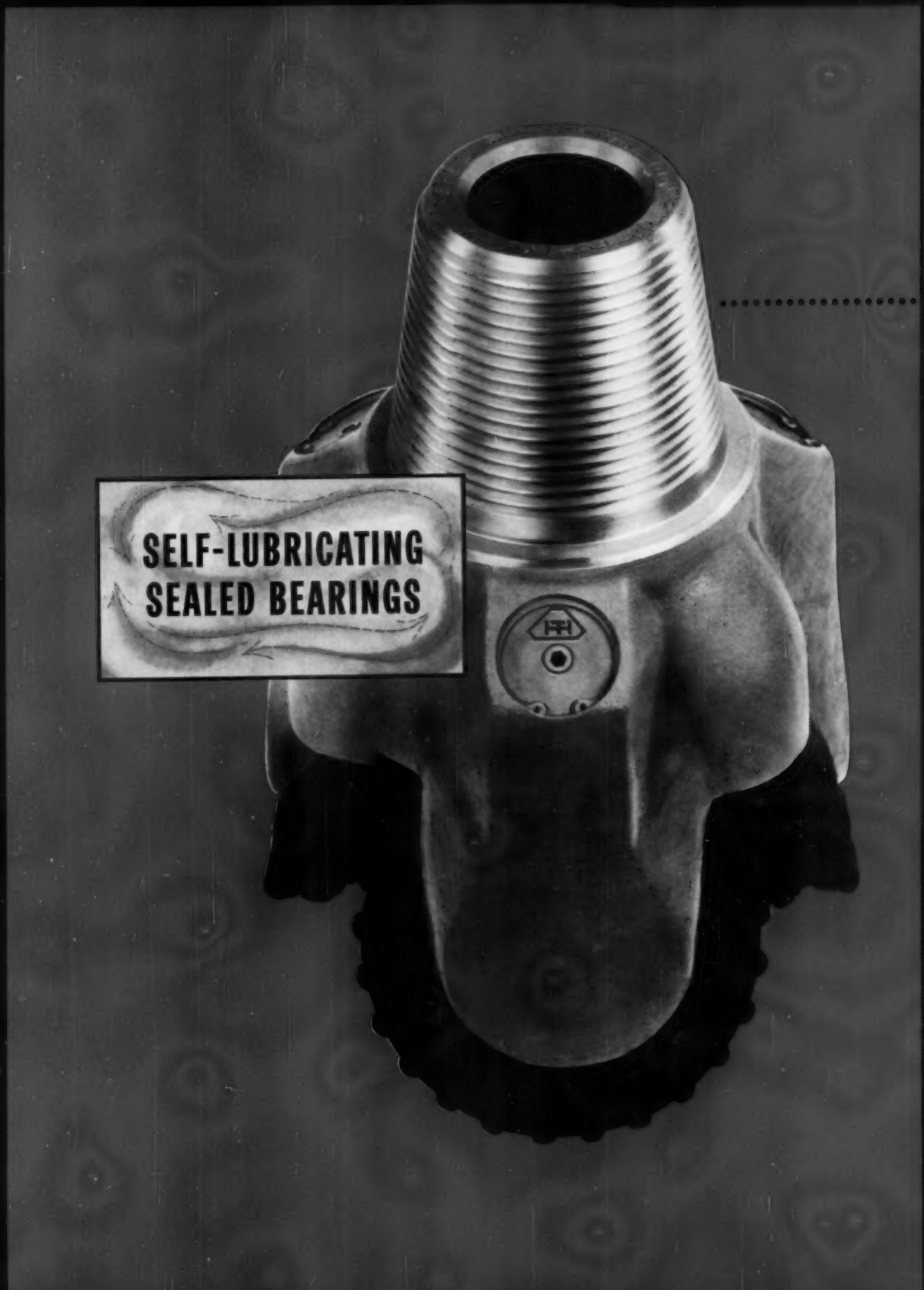

SELF-LUBRICATING
SEALED BEARINGS

.....Another Major Contribution to Rotary Drilling by Hughes

The *self-lubricating* Sealed Bearing bits coming off the production line at Hughes represent the most important breakthrough in rock bit design since the introduction of the Hugheset bit.

By greatly increasing the footage drilled per bit, the *self-lubricating* Sealed Bearings are making possible further major savings in round-trip time.

Demand for these history-making bits is still far in excess of supply . . . even in face of rising production.

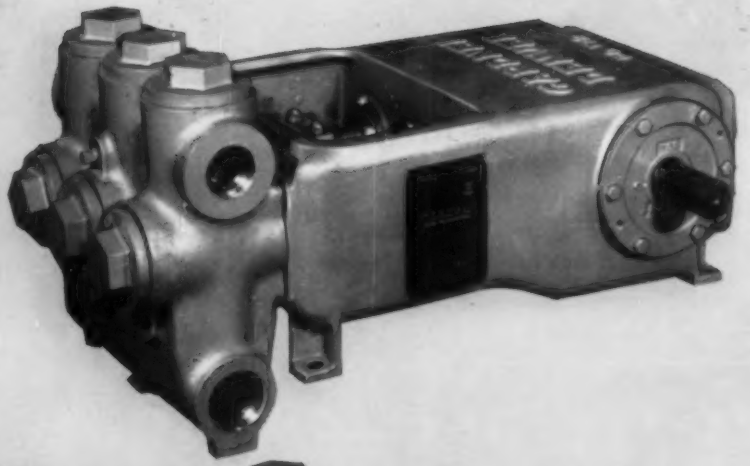
Development of the *self-lubricating* Sealed Bearing bits proves that you can always look to Hughes for the most advanced rock bit designs.

HUGHES TOOL COMPANY

ORIGINATOR AND WORLD'S LEADING DEVELOPER OF CONE-TYPE ROCK BITS

PQ-2
2¼ x 2 triplex plunger pump

15 hp input at 500 rpm
Plunger load: 1660 lb.
Capacity from 51.6 gpm at 425 psi
to 10.2 gpm at 2140 psi



PS-25
2¾ x 2½ triplex plunger pump

30 hp input at 500 rpm
Plunger load: 2690 lb.
Capacity from 96.2 gpm at
455 psi to 12.7 gpm at 3000 psi

TWO NEW

Gardner-Denver waterflood pumps with stamina for continuous service

These compact triplex plunger pumps are Gardner-Denver engineered with rugged reserve for trouble-free waterflood operation. Like all Gardner-Denver waterflood pumps, the PQ-2 and PS-25 are built for long-lasting duty. They include top-quality construction features.

STANDARD EQUIPMENT

- Gardner-Denver Colmonoy plungers
- Gardner-Denver wing guided bronze valves
- direct drive through double extended crankshaft
- one-piece aluminum bronze fluid cylinder
- removable stuffing boxes
- insert-type connecting rod assemblies
- full splash lubrication
- Timken main bearings

OPTIONAL EQUIPMENT

- stainless steel valves
- ceramic plungers
- plunger packing lubricators

For complete details, write for bulletins.

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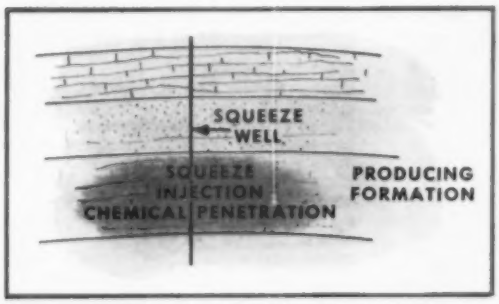
Visco Squeeze Treatment Chemicals Designed to Fit Varying Well Conditions

Corrosion Control Lasts, Costs Less with New Visco Formulas, Methods

Squeeze treatment in producing wells continues to grow in importance as an economical, long-term method of obtaining effective corrosion control. It is simply the pressure injection of corrosion inhibitor chemical into the producing formation, from which it is released in approximate proportion to produced fluid volume over a period of time—anywhere from two to sixteen months.

Visco has found squeeze treating of sufficient interest to producers to justify development of specialized chemicals and techniques to permit most effective use of the method.



Squeeze technique forces chemical corrosion inhibitor into formation around well bottom. Chemical is carried back with produced fluid. The excellent film persistency of Visco squeeze treating chemicals assures long-lasting, low-cost well protection.

Effects of Formation

Producing formation composition, porosity permeability and position can have an important bearing on the success of squeeze treatment corrosion control . . . They are important considerations in the development of special Visco formulas for this purpose.

Determining Chemical Type

As with any operation affecting producing formations, experience is the most dependable guide. Chances are great that the conditions you have in your area have been closely paralleled by other Visco squeeze treating experience. Further, Visco Formulas such as

Visco's J. P. Stanton, Product Manager for Corrosion Control Chemicals, discusses factors considered important in assuring effective squeeze treatment.

S-1390X, 956, S-1339X, were developed to broaden the effectiveness of corrosion control with squeeze treatment, and so are a big help in pinpointing the best chemical and method to apply to specific well characteristics.

Field Experience

Squeeze treating can offer some substantial cost and time advantages for effective corrosion control in many types of producing wells . . . BUT, probably more than any other treating method, squeeze treatment demands skill and experience, as well as effective chemicals, to assure success. No one is better equipped than Visco . . . *we* firmly believe no one else can do as well for you.

Help, Now

Visco action toward being useful in your activities is as close as your phone—and nearly as quick as picking it up. Your move.

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Visco. . . . ***Serving the Oil Industry through Practical Applied Science***

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RUNNING TOUR with MEN in the INDUSTRY

▸ Sinclair Oil and Gas Company has appointed **F. F. Wright** as assistant manager of West Texas division in Midland, and **Henry C. Calhoun** has been placed in charge of conservation and proration activities.

Appointed to new posts are **R. P. Harder,** division geologist, South Texas division in Houston, Texas; **A. D. Brixey Jr.** division geologist at Houston; **W. D. McEachin,** division geologist at Fort Worth, executive assistant with general staff geological department.

J. K. Lydecker has been named division exploration superintendent for division headquarters in Fort Worth.

▸ Bradco Oil & Gas Company and Bradco Associates has announced that **Dr. J. Brian Eby,** consulting geologist in Houston for 13 years, and **Walter L. Williams**, consulting petroleum engineer, have become associated with the firm.

▸ Well Completions, Inc. has promoted **Lyndon P. Harman** to vice president. He will continue as sales manager of the Denver, Colorado, firm.

▸ Lone Star Producing Company has named **B. P. Nixon** as production superintendent for the Oklahoma district, headquartering in Duncan.

WILL NOT FLUORESCE!
ABOVE-ground reasons for specifying PHENO-SEAL
An encouraging sign—core sample oil fluorescing a brilliant purple under the pale blue rays of the Black Light. If it's oil and not a fluorescing lost circulation material that's been dumped down the hole. PHENO-SEAL will not fluoresce . . . cannot confuse core analysis.
And flat-particled PHENO-SEAL saves pumps and valves! It has no "wedging" or "fracturing" effect common to the 3 dimensional materials. Even the largest PHENO-SEAL particle pumps flat much as a dime, when held between thumb and forefinger, will slip into horizontal position as pressure is applied.
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Lafayette, La. CE 5-6945
Circulation, Inc.
Borger, Texas BR 4-3033
Pampa, Texas MO 4-2671

▸ Canada-Cities Service Petroleum Corporation has elected **D. E. Anderson** and **C. E. Cole** of Calgary as vice presidents.

▸ Phillips Petroleum Company has named **W. A. Roberts** division production superintendent, central division, in Oklahoma City.

▸ Honolulu Oil Corporation, Western division, has announced three promotions. They are **R. M. Dewar,** manager, field operations; **H. F. Pohlmann,** Western division petroleum engineer, **C. F. Meacham,** assistant manager, field operations, construction and services.

▸ Delhi-Taylor Oil Corporation has made several promotions in production division. They are **O. Wayne Crisman,** general manager of production division in Dallas; **J. H. Doughman,** manager of production engineering; **H. P. Kerr,** manager of production technical service department, and **W. S. McCready,** assistant manager of production technical service department.

▸ American Institute of Mining, Metallurgical and Petroleum Engineers has named **Lloyd E. Elkins** as president-elect to assume office in 1962. Elkins is production research director of Pan American Petroleum Corporation in Tulsa, Oklahoma.

▸ Continental Oil Company has promoted **John R. Hultman** of Denver, Colorado, assistant division geologist, Rocky Mountain region.**G. F. Gibbins,** Denver City, Texas, has been named superintendent of Odessa production district.

▸ Northern Natural Gas Company of Omaha promotions are **David Lage, Jr.,** supervisor of clerical service, Omaha, Nebraska; **Harold Barrett,** supervisor of operations, Omaha; **Wayne Brown,** gas engineer, Omaha; **Orville Bruce Jones,** well test engineer, Liberal, Kansas; and **James Welsch,** well test engineer, Liberal, Kansas.

▸ **George His** is now associated with **Edman R. Zink** in firm of Zink and His, petroleum geologists in San Antonio, Texas.

▸ General Geophysical Company (Bahamas) Ltd. of Tripoli, Libya has appointed **C. W. Penny** as vice president and general manager.

▸ Lion Oil Division of Monsanto Chemical Company announces appointment of **Lloyd R. Hale** as safety supervisor of production and exploration department, with headquarters in Houston, Texas.

▸ **John H. Weems** has joined geological staff of Associated Oil & Gas Company in Houston.

▸ King-Stevenson Oil Company, Inc. has appointed **Russell E. Hayward** as vice president of King-Stevenson Oil, Ltd., the company's Canadian subsidiary. He will manage all Canadian operations from Calgary, Alberta.

▸ **Michael A. Stone** has joined the staff of Stephens Engineering, petroleum engineers in Wichita Falls, Texas. He is a petroleum engineering graduate of University of Texas.

▸ Henderson and Lynn, consulting petroleum engineers, has been recently formed as a partnership in Midland, Texas.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

▸ Sun Oil Company. **Dr. Richard C. Weart,** who has been on an assignment in Paris, France, has been named head staff geologist for foreign operations department at Philadelphia. **Thomas F. Ritter** will be assistant head staff geologist.

Five executive changes and appointments at Mid-Continent Production Division Headquarters in Tulsa have been announced. **Guy E. Campbell** is now division manager, **William R. Gannaway,** assistant division manager; **J. Edward Green,** assistant division chief geologist, **Jack G. McQueen,** division manager, land department; and **Floyd T. Gates,** assistant division manager, land department.

New assignments in geological department of Gulf Coast Production division are **Wallace W. Rangeler,** senior research geologist, **Herbert L. Durgan,** senior research geologist; **Allen M. Borland Jr.,** assistant to division chief geologist; **W. T. Torie Jr.,** senior geologist, regional geologist in charge of development; **Fred H. Christian Jr.,** senior geologist, assistant regional geologist in development section.

▸ Shell Oil Company has named **Powell A. Dennie** assistant to vice president of Pacific Coast Exploration and Production area.

▸ **Maynard M. Stephens,** formerly dean of school of petroleum and physical sciences of Midwestern University at Wichita Falls, Texas, will devote full time to his consulting practice. He has maintained consulting and oil interests as Maynard M. Stephens Company, petroleum and geological engineers, along with his duties at Midwestern.

▸ Humble Oil & Refining Company has appointed **Merrill W. Haas** as exploration vice president. He will be responsible for coordinating all exploration activities.

▸ Controllers Institute of America has elected new officers. They are **C. Milton Allen,** controller and assistant secretary of Trunkline Gas Company, vice president; **Claude C. Harris Jr.,** controller of Union Texas Natural Gas Corporation, vice president; **Walter R. Daniel,** secretary and assistant treasurer of Western Natural Gas Company, secretary-treasurer; and **Daniel B. Lovejoy,** senior vice president Union Texas Natural Gas Corporation, director.

▸ Pan American Petroleum Corporation has appointed **Fraser H. Allen** as chief engineer. Allen was formerly division engineer for Pan American's central division in Oklahoma City, and he succeeds **Lewis Finch Jr.,** who was appointed manager of production.

▸ University of Texas has appointed **Dr. Carl Gatlin** as Petroleum Engineering Department chairman. Active in petroleum industry for many years before becoming a teacher, he joined university faculty last year as a visiting associate professor. He succeeds **Dr. George H. Fancher,** who has become vice president in charge of production research for an oil company at Tulsa.

▸ **Charles B. Ammann,** senior petroleum engineer with Sinclair Oil & Gas Company, Tulsa, Oklahoma, is the 1960 recipient of the **Cedric K. Ferguson** Medal awarded by the Society of Petroleum Engineers of AIME, for his paper, "Case Histories of Analyses of Characteristics of Reservoir Rock from Drill-Stem Tests."

Operator Drills 170% More Footage, Increases Bit Life 66% With Seeco-Mul

Inherent Lubricating Qualities Also Broaden Use of Seeco-Mul As Effective E-P Additive

A division drilling engineer for a major in West Texas reported these significant figures after completing an 11,500′ well with a Seeco-Mul mud. Oil-and-water emulsion drilling fluids are being used extensively by the division, and detailed records were maintained on both field and exploratory wells drilled with company rigs. Here's what Seeco-Mul did:

- *Increased bit life 66%.*
- *Increased footage per bit 170%.*
- *Increased penetration rate 66%.*
- *Saved $9,000 in one interval.*

Not only did they get the benefit of the extreme-pressure properties in Seeco-Mul, which extended bit life, but also attributed to the Seeco-Mul system were "a more nearly gauge hole, fewer round trips, less wear on the rig and equipment, more rig time in actual drilling, and less wear on pumps, liners, and the drill string."

On another test, "the average rate increased 45% and the footage-per-bit increased 86% in a single 800′ interval. Ten fewer bits were used, and 122 less rig hours, for an estimated savings of $7,500."

And here's what the company said about $2,540 spent for a product *specifically sold for bit lubrication:* "No increase in bit bearing life or penetration rate was achieved . . . on the basis of the test results (higher drilling costs with no improvement in bit life), further use was discontinued until more favorable results could be anticipated to justify the added expense."

Seeco-Mul, often run in so-called soap drilling fluids to lower the surface tension, is a chemical additive with superior wetting abilities. In addition, Seeco-Mul is an efficient E-P agent. It deposits an extremely tough lubricating film that will withstand high pressure and successfully reduce metal-to-metal contact of the bearing surfaces in the bit.

DRILLING PERFORMANCE IN 6¼" HOLE

Well No.	H-4	D-2
Type Mud	Seeco-Mul CMC low solids	CMC low solids
Interval	9,999-10,787	9,999-10,803
Footage	788	804
Bits	8	22
Rotary Hours	126	210
Rotary and Trip Hours	174	342
Weight	35	25
RPM	38 to 50	60
Feet Per Hour	6.3	3.8
Feet Per Bit	98.5	36.5
Hours Per Bit	15.8	9.5
Penetration Rate Increase	65.8%	—
Footage Per Bit Increase	169.9%	—
Cost Per Foot*	$11.20	$22.54
Mud Cost (including mud-up)	$1,470.00	$1,150.00

*Total rig time × $45 per hour + number of bits × $124.30 ÷ interval footage.

Seeco-Mul is making hole faster and saving money for operators from the Gulf Coast to the Permian Basin. If you would like to report similar savings in rig time — increased bit life — more footage per bit — save rig hours — ask your local mud dealer about Seeco-Mul, or write to us for technical literature and a lab sample. We'll be glad to give you full particulars without obligation.

Make a good mud better... use

CROSSETT **Seeco-Mul** **DRILLING MUD ADDITIVE**

Manufactured by the Chemical Division of The Crossett Company, Crossett, Arkansas

Seeco-Mul is the dried flake form of a compound of the sodium salts of abietic, linoleic, and oleic acids, together with quantities of wood tannins and lignins.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

It's New

Drilling - Producing Equipment

Cushion-Type Couplings Have Pan-Shaped Element

Two cushion-type couplings feature a pan-shaped rubber flexing element of entirely new design for high speed or high torque applications.

Dodge designates their couplings as Para-flex High Speed and Para-flex Flywheel types. They were designed to operate at higher speeds and transmit greater torque than the original Standard Para-flex with a rubber tire-shaped flexing member of cord and rubber construction.

Both new types are designed to accommodate, either singly or in combination, angular and parallel shaft misalignment and end float. They also absorb torsional vibration and cushion shock loads.

Designed for speeds up to 5230 rpm, coupling may be used with electric motors or internal combustion engines. They operate equally well on low-speed applications where torque requirements are high. *Dodge Manufacturing Corporation.*

Circle number (1) on reply card.

Champions of Endurance!

W.C. NORRIS SUCKER RODS

Write for complete Sucker Rod Bulletin

W. C. NORRIS, MANUFACTURER
DIVISION OF DOVER CORPORATION
P. O. BOX 1739 • TULSA, OKLAHOMA

NORRIS QUALITY
SUCKER RODS
POLISHED RODS COUPLINGS

BRANCHES: Great Bend, Kansas; Corpus Christi, Houston, Kilgore, Odessa, Wichita Falls, Texas; Oklahoma City, Oklahoma; Salem, Illinois; Casper, Wyoming; Farmington, New Mexico; Edmonton, Alberta, Canada.

Buy From Your NORRIS Distributor

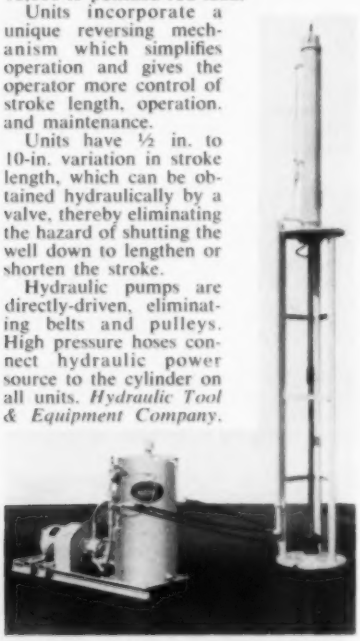
Hydraulic Pumping Units

A new line of pumping units, HYTECO's Pacific line, are hydraulic units manufactured in different sizes and capacities. They range from a 2-ft stroke, 3500 lb polish rod load to 10-ft stroke, 18,000 lb polished rod load.

Units incorporate a unique reversing mechanism which simplifies operation and gives the operator more control of stroke length, operation, and maintenance.

Units have ½ in. to 10-in. variation in stroke length, which can be obtained hydraulically by a valve, thereby eliminating the hazard of shutting the well down to lengthen or shorten the stroke.

Hydraulic pumps are directly-driven, eliminating belts and pulleys. High pressure hoses connect hydraulic power source to the cylinder on all units. *Hydraulic Tool & Equipment Company.*



Circle number (2) on reply card.

Drill Pipe Elevator

A Champion series center-latch drill pipe elevator developed by Web Wilson and manufactured by Baash-Ross Division of Joy Manufacturing Company have capacity ratings from 100 to 350 tons and handle all drill pipe sizes from 2⅜ to 5½-in.

Elevators are designed for balance, and this is most noticable in the open position.

Safety features include a massive safety latch designed into the body where it is free from damage and prevented from accidental opening. Exclusive slanted hinge pin transfers part of the load on the elevator into a closing force, relieving strain on the latch.

Maximum strength and wearing properties are assured by the use of chrome-molybdenum alloy steel for all parts.

Chrome-molybdenum alloy steel is used for all parts of the elevator. A strong coil spring holds elevator open, and they are available for tapered or square-shoulder tool joints, either screwed or welded on. *Baash-Ross Division.*

Circle number (3) on reply card.

Computer System

Libratrol-1000, an advanced process control digital computer system, accepts data directly from analog instrumentation and provides closed-loop operation.

Completely transistorized, system includes an advanced memory unit, new developments in read and write head design, and a built-in voltage-to-digital converter. These features provide closed-loop control.

Departure from conventional design has produced a drum memory with more advanced physical characteristics, using new developments in transistors and advanced design concepts in read and write head circuits.

System is a two-address, electronic, digital computer system designed especially for new, advanced areas of process control. It operates in serial, binary mode and offers expanded data-handling capabilities because of the 8000-word memory and a new concept in data placement and recovery. *Librascope Division, General Precision, Inc.*

Circle number (4) on reply card.

Slim-Hole Completion Sub-Surface Pumps

Harbison-Fischer has introduced a new line of subsurface pumps for slim-hole completions.

Called Little Squirt, the pump is available in a full range of slim-hole completion sizes. Pumps are available in four rod pump sizes and five tubing pump sizes, with metal or cup plungers.

Pumps can be run in either single or multiple-string wells with 1¼ or 1½-in. tubing. *Harbison-Fischer Manufacturing Company.*

Circle number (5) on reply card.

Overlapping Dome Starters, Breakers

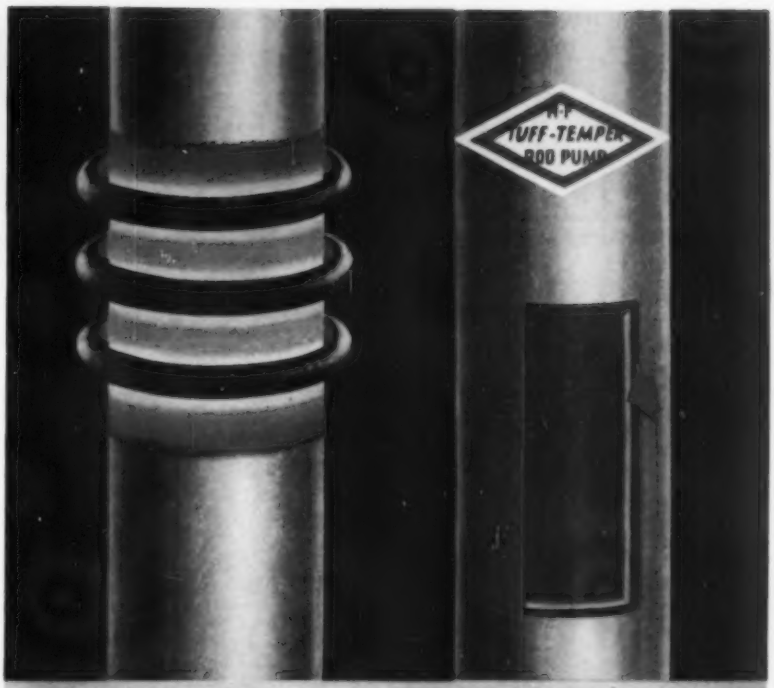
Pyle-National has introduced a new line of motor starters, circuit breakers, and combinations of both. Designated as Model 60, Series ECS Pylets, all types are explosion-proof, dust-tight and weather-resistant for indoor and outdoor use under severe environmental conditions normally encountered.

Novel features include cast-aluminum threaded enclosures with stainless-steel exterior hardware for positive weather protection and corrosion resistance.

Enclosure consists of a central body externally-threaded at top to accept internally-threaded overlapping dome which provides natural shedding of water or process drippings. Body is oppositely threaded at bottom to duplicate water shedding effect through overlapping externally-threaded inverted lower dome.

Both domes have a safety interlock to prevent inadvertent opening of enclosure in hazardous locations when operating handle is in the "on" position. *The Pyle-National Company.*

Circle number (6) on reply card.



Through the Magic of Electronics...

Tuff-Temper Barrel Tubes Run Longer in Pumping Abrasive Fluids

For the longest and most dependable service from a sub-surface pump running in abrasive fluids, your best choice is a barrel tube with a hardened wearing surface. From that point on, the rest is easy: Run a Tuff-Temper pump — the Best Pump in the Oil Patch to resist the abrasive effects of sand, scale, etc., that would cause undue wear and shorten the life of the pump.

Electronics puts the toughness and the temper in Tuff-Temper barrel tubes — where the wear-resisting properties are most needed. Each tube is heat treated by high-frequency induction hardening machines, the latest and surest method for exact control of temperature for uniform hardness and dense grain structure. The hard wearing surface produced by this method extends to a depth of 1/32", and the outer portion remains ductile and shock-resistant.

After the induction hardening process, the tubes are straightened on special machines, the inside working surface is expertly honed and polished to a mirror finish, and each barrel is checked against a full set of A.P.I. gauges. Heavy-duty pumps for deep-well production and chrome-plated plungers for extra hard wear can be furnished if desired.

Leading stores carry Tuff-Temper rod and tubing pumps in a wide range of A.P.I. types and sizes. You can obtain complete details and illustrated literature from your own store, one of our many factory warehouses or field representatives, or by writing to us at P. O. Box 2477 in Fort Worth. There is no obligation, of course.

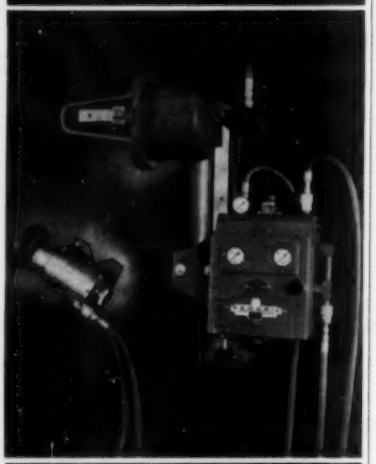
"BEST PUMPS IN THE OIL PATCH"

HARBISON-FISCHER MFG. CO.

FORT WORTH

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

The NEW GEODRIL® AUTOMATIC DRILLER



gives you

1. LONGER BIT LIFE
2. FEWER TRIPS
3. STRAIGHTER HOLE

The GEODRIL Automatic Drilling Control was developed, tested and proved in the field by The Geograph Company, manufacturers of the internationally accepted Geograph Mechanical Well Logging Recorder.

The new, automatic GEODRIL control has many outstanding features and offers the drilling contractor dependability, economy and safety.

Service for the GEODRIL Control is provided by the experienced personnel of Geograph Oil Field Services. Their reputation for service is backed by over a fifth-of-a-century of experience in the oil fields.

When you drill your next well, specify the NEW GEODRIL Automatic Driller for maximum drilling efficiency. For additional information, contact your nearby Geograph Oil Field Services office.

GEODRIL® AUTOMATIC DRILLER

GEOLOGRAPH® OIL FIELD SERVICES
P. O. Box 1276 • Oklahoma City 1, Okla.

Cemented Tubing Mill

A-Z International Tool's new piranha mill, named after the South American killer fish that can strip a full-grown cow in minutes, is specifically designed to mill cemented tubing at high penetration rates, even if the tubing is alongside the casing wall.

Mill has three cutters in the ID that will mill up the core of metal usually left by regular cutters. The piranha mill cuts as a regular junk mill when the tubing is centered in the casing. It should not damage or cut the casing wall, according to the manufacturer. *A-Z International Tool Company.*

Circle number (7) on reply card.

Fluid-Loss Preventative

Adomite-Mark II, a chemical designed to give improved performance in oil field fracturing operations, has been developed by Conoco's petrochemical department.

An improved version of Adomite, the additive is used to prevent fluid loss from fractures to the surrounding matrix, which makes possible a greater fracture radius for a given volume of fracturing fluid and permits higher sand-oil ratios without danger of sandouts.

Fluid loss properties of the chemical are not appreciably altered by changes in temperature, pressure, or viscosity, the company states, and it will tolerate up to 20% water in fracturing oil without detrimental effect. *Continental Oil Company.*

Circle number (8) on reply card.

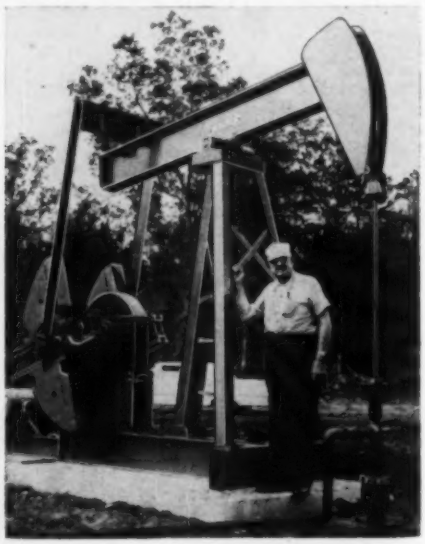
Tubing Head Devised For Shallow Wells

Collar-suspension tubing head, Type HSR Tubing Head, is now being marketed by Hercules Tool for use on tubingless completions, water floods, and shallow-pumping wells of 2500-ft depth or less. Test pressure is 500 psi and maximum recommended load is 30,000 lb.

Tubing is suspended with coupling resting on a ductile iron support ring, and tubing head is packed off around coupling by compressing neoprene packing ring between the split metal packing and support ring. Compression is applied by packing gland that is drawn down by two gland bolts.

Head is available in 3½, 4½ or 5½ OD female casing sizes. The 3-in. size body, with 3-in. minimum bore, suspends ¾-in. to 1½-in. plain or EUE tubing. The 4½ and 5½-in. OD bodies have a 4-in. minimum bore and suspend ¾-in. to 2½-in. to 2½-in. plain or EUE tubing. *Hercules Tool Company.*

Circle number (9) on reply card.



STOCKED BY YOUR LOCAL SUPPLY STORE

PROVED ECONOMY

The best way to judge the merits of any pumping unit is by checking operating cost.

JENSEN JACKS PROVE they're the best buy. They pump more oil for less money. Work longer with less down time.

Get the facts on **JENSEN** before you equip that next well — Chances are you'll get a **JENSEN** — "the most dependable name in pumping units."

Made by **JENSEN BROS. MFG. CO., INC.,** **P. O. Box 477-B, Coffeyville, Kan.**
Export Office: 250 Park Avenue, New York 17, N.Y.

JENSEN JACKS

Medium-Hard Drilling Bit

Varel has designed and manufactured a formation-type bit, VH2-G, for faster drilling of medium-hard formations.

Available in sizes 7⅞, 8¾, and 9 in., new bit is designed for drilling in shale, slate, hard anyhdrites and limestone. Bit has chiseled teeth with a reinforcing L on the gage reinforced with tungsten carbide. *Varel Manufacturing Company.*

Circle number (10) on reply card.

Missile Steel Used

Axelson is using Triple-H, a chromium-nickel-molybdenum alloy developed for missiles, to increase strength and corrosion resistance in polished rods.

Hydraulic units relieve sucker rod stretch by permitting longer strokes, and one model moves sucker rods 31 ft up and an equal distance back down at the rate of 6½ strokes a minute. *Allegheny-Ludlum Steel Corporation.*

Circle number (11) on reply card.

Shaped Charge Developed

Pan Geo Atlas recently introduced to field service its Bull-Jet shaped charge for use in 3⅛-in OD steel case retrievable guns. Charge is a smaller version of company's Atlas-Jet charges for 4 and 5-in. hollow-carrier retrievable guns. *Pan Geo Atlas Corporation.*

Circle number (12) on reply card.

Plastic Pipe Formed

An isopolyester resin has been applied for the first time to manufacture plastic pipe. Pipe made with the new resin, Dion-Iso DR-661, will operate satisfactorily in continuous duty up to 350 F, and it will resist acids, alkalies, and other corrosive materials.

Pipe is available in 4, 6, 8, 10, and 12-in. OD sizes. *Reflin Company.*

Circle number (13) on reply card.

Sand-Control Screen

Halliburton has an unusual development in sand control—a screen with outer area covered by sand held together by resin.

Screen employs a sand face as the direct screening medium without an outer covering of metal. This provides a natural buffer which is inert and compatible with producing formations.

Sand screen gives exposed surface flow area which is several times larger than conventional liners. This diffuses formation sand over screen's entire surface rather than concentrating it at restricted points of entry.

Mixture in the screens has a compressive strength in excess of 3000 psi, shear strength in excess of 800 psi and tensile strength in excess of 600 psi. Permeability on the consolidated sand is 23 darcies and porosity is 26%.

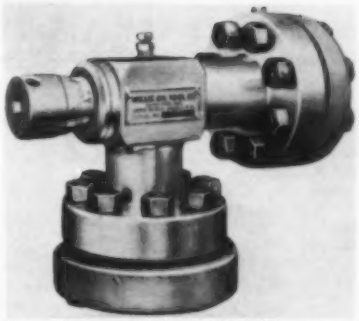
Length of the screens is 6 ft, and they are available in two sizes, 3.9-in OD and 5.75-in. OD. Each length is equipped with a centralizer and collar. *Halliburton Company.*

Circle number (14) on reply card.

Valve for Multiple Orifices

Willis Multiple Orifice Injection Valve retains the advantages of a needle valve's micro-fine adjustments without their cutting and chattering disadvantages. The Willis Valve has exceptionally low adjustment torque at very high pressures and meters fluids from a minute flow to full line flow with less than a one-quarter turn of the stem.

Metering discs in the valve are capable of withstanding extremely corrosive fluids. Valve is available in either L or inline flange facings. *Willis Oil Tool Company.*



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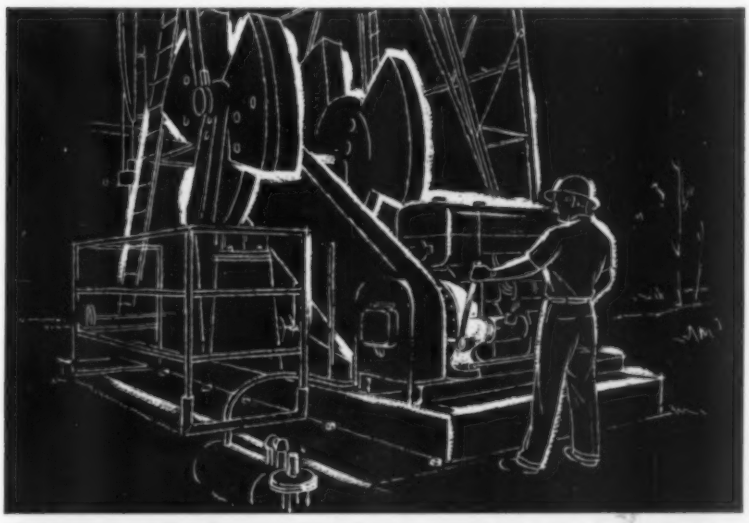


DEPENDABLE PUMPING

with Rockford Power Take-Offs

It's no wonder why more and more oil men specify Rockford PTO's. These maintenance-free PTO's offer higher torque capacities, better heat dissipation, less lever pressure, and positive engagement. Rockford's infinite-control adjusting ring provides longer life. Smooth and instantaneous power is transmitted from any internal combustion engine to your working oil field equipment.

Write today for illustrated brochure.

ROCKFORD PTO

ROCKFORD CLUTCHES

ROCKFORD CLUTCH DIVISION BORG-WARNER

1303 EIGHTEENTH AVE.
ROCKFORD, ILLINOIS

Export Sales
Borg-Warner International
36 So. Wabash, Chicago, Ill.

New Literature

Wide Spectrum Biocide

Hagan B-2, a wide spectrum biocide for use in oil field operations, is subject of a new bulletin just issued by Hagan Chemical & Controls.

Effective against most microorganisms, biocide is exceptionally toxic to sulfate-reducing bacteria even in concentrated brines. According to manufacturer, biocide provides protection against corrosion by forming an organic film on metal.

Biocide is used specifically for treating water injection systems, producing wells, and water disposal systems. *Hagan Chemical & Controls, Inc.*

Circle number (16) on reply card.

Pumping Motors, Controller, Gas Turbine Engine

General Electric has prepared bulletins on oil well pumping motors and controllers, and a gas turbine for potential application in oil well servicing and crew boat propulsion.

Bulletin GEA-6546E, six pages, describes features of new 3 to 75-hp, high-torque, high-slip Tri-Clad 55 pump motors. Motors are designed to operate at high torque to overcome unusual load conditions and eliminate rocking the beam. Cutaway view shows internal construction, rating and dimension data are provided, and bulletin also describes complete line of specially-designed, outdoor-duty controllers for full-voltage starting of polyphase motors up to 100 hp.

Bulletin SAE-109A on Model 720/722 gas turbine describes General Electric's performance specifications, dimensions, and installation data, fuel specifications, a development history, summary of reliability testing, exploded and cutaway views of engine plus a listing of current field installations and a review of application potential in area of oil well servicing, marine propulsion, and power generation. *General Electric Company.*

Circle number (17) on reply card.

Multi-Speed Chart Drives

Multi-speed chart drives, accessories for use with Minneapolis-Honeywell, Wheelco, Bristol, General Electric, and Leeds and Northrup strip chart recorders, are described in this catalog. Complete application details presented include chart showing all eight chart speeds provided by each model, instructions for ordering proper model for any standard recorder and photographs of units installed.

Text describes units, advantages of quick, easy chart speed change replacing change gears, potential savings in chart paper costs, ability to match chart speed and test requirements with improved resolution and readability. *Insco Company.*

Circle number (18) on reply card.

Needle Valves, Fittings

Bulletin 420, just published by American Meter, provides full details on companies forged steel needle valves and fittings for heavy duty service to 5000 psi. Needle valves and fittings are used for many gas measurement and control applications, and are available in forged carbon steel and forged stainless steel. *American Meter Company.*

Circle number (19) on reply card.

Rock and Insert Bits

Varel exploration rock bits and insert bits are described in two additional catalog pages which are available to customers and dealers. Bits show latest designs of VH1, V1, V2, V3, and V4 rock bits. Prices show economics of using bits and details are given in tables for sizes 2 15/16 through 5⅝-in. three-cone bits; and 2⅛ through 4¾-in. two-cone bits. Insert blade bits are described and sizes from 2⅞ through 6¼-in. are tabulated with all related information and prices. *Varel Manufacturing Company.*

Circle number (20) on reply card.

Hydraulic Acoustic Filter

The PULSCO acoustic filter reduces liquid borne noises in hydraulic systems, and electronic cooling systems, removing as much as 99% of the noise energy. Units are applicable both to high pressure hydraulic systems to remove noises from positive displacement pumps and to water systems to eliminate noises caused by centrifugal and turbine type pumps. *Pulsation Controls Corporation.*

Circle number (21) on reply card.

Water-Control Chemicals

Bulletin on Triton Trio shows uses in raising injectivity indices in waterflooding, removing water from drowned gas wells, foaming-off intruding water while air drilling. X-100 is used for cleaning out injection wells, X-102 is used for foaming out water, light and heavy brine, and particles from drowned gas wells, and X-165 is used for foaming out water and drill cuttings during air drilling. *Rohm & Haas.*

Circle number (22) on reply card.

CAMCO Type C

SLIDING SLEEVE

dependable shifting action with positive low-friction, dual seals

Installed in single or multiple tubing strings, the new Camco Type C Sliding Sleeve can be used for killing wells, spotting acid or fracturing, and provides a means of circulation for permanent-type well completions. It is well suited for directing flow from casing to tubing. Any number of sleeves may be run in a tubing string and operated selectively with shifting tools in common use.

Collar O. D. and essentially full-opening tubing I. D. are ideal for multiple completions. Tensile strength exceeds that of P-105 tubing. Type C Sleeves are corrosion resistant and feature pressure relief slots and low friction, high pressure circulating-port seals.

For more information, contact your CAMCO representative or write:

C-608

P. O. Box 14484 · 7010 Ardmore Street · Houston, Texas

Well Flow Inducers

Tretolite has announced an 8-page brochure describing Swabstix Flow Inducers.

Booklet explains new well-swabbing concept, how and where flow inducers should be applied, and it contains performance data on a number of wells. *Tretolite Company.*

Circle number (23) on reply card.

Electro-Chemical Cutter

Electro-chemical wire line tool is designed to cut tubing without distortion on either OD or ID. Bulletin No. 801 describes its use for fishing operations or for through-tubing work. *McCullough Tool Company.*

Circle number (24) on reply card.

Air and Gas Drilling Equipment, Techniques

Air and gas drilling compressors and boosters, tools, chemicals, and technical services are described in eight-page Well Completions, Inc. catalog for 1960-61. Company's line of Tornado double-acting, two-stage compressors for air and gas drilling, and the Tornado boosters for high-pressure application are described. Catalog also includes section on foaming agents, drying (anti-balling) chemicals and associated pumping units. New air drilling techniques are described. *Well Completions, Inc.*

Circle number (25) on reply card.

Vertical Turbine Pumps

Layne Volatile Liquid Pumps, new three-color, six-page bulletin, has just been published by Layne & Bowler. Bulletin includes cross-section drawings of standard short-coupled vertical turbine pump and canned-type turbines vertical pump with uses and applications illustrated. *Layne & Bowler, Inc.*

Circle number (26) on reply card.

Two-Zone Subsurface Pumps and Chokes

Bulletin covering features and applications of D plus B Two-Zone Subsurface Pumps and Chokes has been published by Continental-Emsco Company. Illustrated views of pumps and parts are included.

Complete 12-page bulletin includes engineering tables, a size and description table, and a sample calculation of an installation. *Continental-Emsco Company.*

Circle number (27) on reply card.

Light-Wall Tubing Expanded From Strips

Wolverine Tube has published an 8-page, 2-color brochure on one of their most recent developments, called strubing.

Strubing is a seamless, light-wall tube and will be produced by company in most metals. It is unique since it is processed in strip form and rolled up for compact shipment. Brochure explains how mechanical techniques are used to expand strip into tubular form. *Wolverine Tube Div.*

Circle number (28) on reply card.

Drilling Rig, Swivels

Two National Supply Bulletins describe consolidated drilling rig and swivels.

Type 80-B consolidated rig is described and illustrated in 16-page Bulletin No. 516. Rated at 1000 hp, rig was designed for drilling in 8000 to 12,000-ft depth range. Bulletin contains over-all photographs and close-ups of various components of rig. Engineering and operating specifications, a shaft-speed diagram, typical foundation plan, and performance curve are included.

Bulletin on swivels gives complete tabulation of specification from shallow wells of 1000 ft or less to deepest well below 20,000-ft mark. *National Supply Company.*

Circle number (29) on reply card.

Shale Shakers, Mud Tanks

Illustrated two-color folder describes Rumba Shale Shaker built in England by Niagara under license from Hutchison Manufacturing of Houston. Also described are complete systems of mud tanks, ditching, staging, walkways, stairways, water tanks, chemical platforms, sack cutting devices, and related equipment.

Descriptions and specifications of equipment are provided. *Niagara Screens, Ltd.*

Circle number (30) on reply card.

High Temperature Insulation

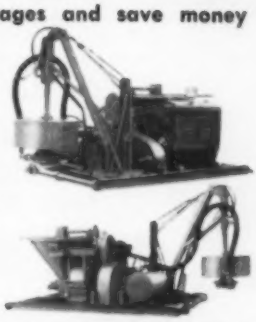
Four-page brochure describes and illustrates Kaylo-Klad high temperature insulation for industrial piping. *Owens-Corning Fiberglas.*

Circle number (31) on reply card.

New Mudmixer Makes Other Mixing Methods Obsolete and Costly

Compare Thompson's field proved advantages and save money

Automatic feed and mixer gives close control of dry muds and chemicals (except caustic soda) and mixer delivers mud to system thoroughly mixed. Actual field tests have proven an *increase in jel yield of 15% to 30%* over hand feed and jet mixing methods. Thompson Mud and Chemical Mixer is a complete unit with pump and power.



SOLD ONLY THROUGH SUPPLY STORES

THOMPSON TOOL COMPANY
Iowa Park, Texas

SUPPLIERS' PARADE

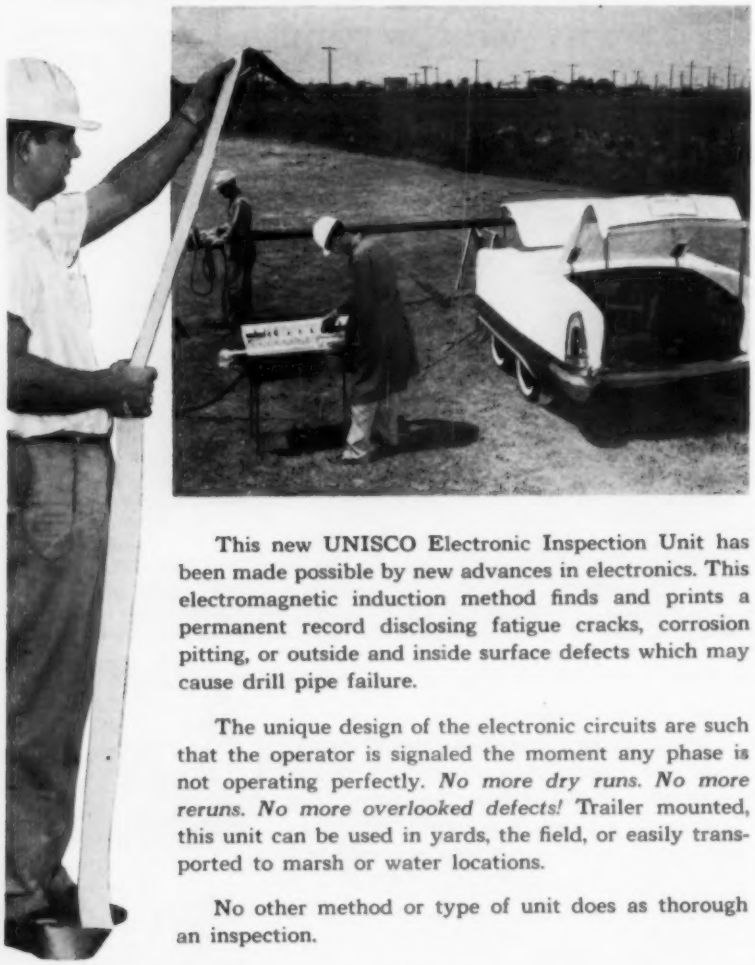
New Companies, Subsidiaries, and Agents

National Supply Company — Eastman Oil Well Survey Company has been appointed exclusive prime distributor of Gammaloy drill collars for export. Oil field supply store has been opened at Roundup, Montana, and J. L. Radden has been transferred as manager.

Garrett Oil Tools—foreign agents appointed are James Bayliss, Brisbane, Australia, covering Indonesia, Borneo, Australia, New Guinea, New Zealand, and the Philippines; Edeco Company, GMBH, Hamburg, Germany, covering West Germany; Anglo-Espanola de Electricidad, S. A., Barcelona, Spain, covering Spain and Spanish Sahara; Macridge Petroleum Equipment-Supply Company S.A.L., Beirut, Lebanon, covering Lebanon, Bahrein, Saudi Arabia, Kuwait, Syria, Jordan, Greece, Oman, Neutral Zone, and Qatar; British Scientific Company, San Fernando, Trinidad, covering Trinidad.

James A. Lewis Engineering, Inc. of Dallas has opened new branches in Long Beach, California and Wichita, Kansas. An affiliated company has been formed also, James A. Lewis Engineering, S.A. with offices in Geneva, Switzerland and representatives in Paris, France.

CALL "UNISCO" FOR THE BEST IN DRILL PIPE INSPECTION



This new UNISCO Electronic Inspection Unit has been made possible by new advances in electronics. This electromagnetic induction method finds and prints a permanent record disclosing fatigue cracks, corrosion pitting, or outside and inside surface defects which may cause drill pipe failure.

The unique design of the electronic circuits are such that the operator is signaled the moment any phase is not operating perfectly. *No more dry runs. No more reruns. No more overlooked defects!* Trailer mounted, this unit can be used in yards, the field, or easily transported to marsh or water locations.

No other method or type of unit does as thorough an inspection.

UNIVERSAL INSPECTION & SERVICE CO.

A Division of Atlas Pipe Inc.

Houston GY 9-9250, New Iberia EM 4-8666, Odessa EM 6-8241

Grant Oil Tool—New branch office has been opened in Kilgore, Texas, and Drew Johnson has been appointed manager.

Continental-Emsco Company has announced five new distributors for company's line of swivel joints and loading arms. They are Gary Sales Company, Detroit, Michigan; Midway Supply Company, Inc., Jackson, Michigan; Mechanical and Electrical Equipment Company, Tulsa, Oklahoma; Calvert-Conel Company, Cleveland, Ohio; and Keystone Pipe and Supply Company, Milwaukee, Wisconsin.

Dowell Division has established a new, modern service laboratory in Liberal, Kansas. Laboratory is fully equipped to handle formation and fluid analyses and other testing required to diagnose well conditions and plan technical treatments.

Welex, Inc. has opened a new service location in McCook, Nebraska. In charge of operation is R. E. Sandlin, sales engineer; and other personnel include L. R. Weathers and J. D. Widders, field engineers.

Rust-Oleum Corporation—Manufacturing plant opened in Haarlem, Holland, new 30,000 sq ft plant, with capacity of 2000 gal per day, will supply rust preventive coatings to about 25 countries.

Core Laboratories, Inc. has moved into new home office and laboratory facilities in Dallas. Modern, two-story structure centralizes company's administrative, engineering and consulting, special core analysis, reservoir fluid, data processing and computing, research, accounting, and equipment development-maintenance departments. Company's employee pension fund financed the $750,000 investment.

Hutchison Manufacturing Company of Houston has appointed Cox Oilfield Equipment Company as Rocky Mountain area representative. Company's headquarters are in Casper, Wyoming.

Jones & Laughlin Supply Division has opened a supply store at Fort St. John, British Columbia. R. C. Dean has been appointed store manager, and W. B. McClelland, salesman for the new store. Coleman Cable and Wire Company has been named a distributor of wire rope, chain and slings for Jones & Laughlin. Coleman Cable's warehouse is in River Grove, Illinois.

Baker Oil Tools has opened a new branch in Citronelle, Alabama. B. J. Gass will manage the service and equipment office. A new branch has been opened in Rio Vista, California, which will be supervised by J. H. Graham, sales and service engineer; and J. J. Laws has been promoted to branch manager of Falfurrias, Texas office.

Walworth Company has announced formation of a new Lubricated Plug Valve Division with sales and service headquarters in Houston, Texas. Company has selected specially-trained personnel within the company to staff the new division with technical and sales personnel located in key cities throughout the country.

Appointments and Promotions

Milwhite Mud Sales Company—**James N. Stratton,** area sales manager, Midland, Texas.

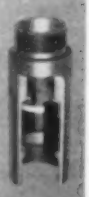
Grove Valve and Regulator Company—**Al Romano,** sales engineer in Southern Louisiana.

Gulf Coast Machine and Supply Company—**Roger Riddle,** Oklahoma City representative.

Let R-u-b-b-e-r Take The Wear

in your sucker rod pumps

IT COSTS YOU LESS THAT WAY



● MARTIN RUBBER & DUCK RINGS give excellent life in dirty abrasive fluids . . . high or low gravity . . . much or little water . . . shallow or deep wells. They last for years in the easier pumping wells. Replacement rings cost comparatively little.

● MARTIN PLUNGER BODIES, precision grooved, drilled and threaded (no underneath fluid passage), usually last for years. Tube or barrel costs are often cut in half.

● The replaceable SYNTHETIC RUBBER GUIDES in MARTIN CAGES last longer than any metal, and the cushioning of the ball increases your ball & seat life. Results are often truly amazing. (Patent No. 2,591,174)

Write for our new 1960 catalog or see it in the new Composite (24th Edition). All products sold thru supply companies.

JOHN N. MARTIN

Manufacturer

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Dowell Division—**J. L. Clifton,** appointed to Tulsa sales staff.

Parkersburg Rig and Reel Company—**S. S. Smith,** promoted to division sales manager for Rocky Mountain division.

Daniel Orifice Fitting Company—**Edward L. Krall,** transferred to sales representative in Odessa, Texas.

Garrett Oil Tools—**Fred L. Magoon Jr.,** promoted to manager of engineering and bolling; **A. Abercrombie,** manager of production planning and evaluation.

Magnet Cove Barium Corporation—**Kinder Chambers,** promoted to staff service engineer in drilling mud department, marketing division in Houston, Texas.

Harrisburg, Inc.—**William S. Davis,** appointed as vice president.

Mandrel Industries, Inc.—**W. J. Gundlach,** chief engineer for Houston divisions.

National Supply Company—**Robert W. Craig,** retired after 38 years of service throughout the world as sales engineer.

U. S. Steel's Oil Well Supply Division—**Edward W. Metters** and **Curtis T. Deehr,** field representatives in Los Angeles; **Harold E. Throop,** field representative in Ventura; and **Donald E. Mosher,** field representative in Coalinga; **John B. Fowler,** field representative at Shreveport, Louisiana.

Hydril Company—**David A. Carnahan,** sales engineer.

Jones & Laughlin Supply Division—Salesmen appointed are **C. W. Thurmon,** Shreveport, Louisiana; and **N. A. Myers,** Lake Charles, Louisiana. Salesmen transferred are **W. C. Blackledge,** Natchez, Mississippi; **N. W. Babb,** New Orleans, Harvey, Louisiana; **L. K. Meredith,** Lindsay, Oklahoma; **H. D. Witt,** McCook, Nebraska; and **J. B. Oujesky,** sales trainee at Lafayette, Louisiana.

Wilson Supply Company, fishing tool division—**W. H. Newman** promoted to general manager, **B. M. "Skip" Scivally,** former manager, promoted to manager of research and fishing tool development program.

General News

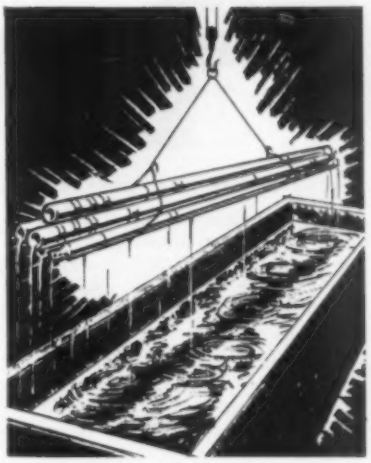
Pan Geo Atlas Corporation oil well service operations have been extended to Mendoza fields, less than 100 miles from the border of Chile. These operations are being directed by company's Argentine subsidiary, Servicios Tecnicos Atlas, S.A.

Walworth Company—One-day seminars are conducted at customer facilities throughout the country by specially-trained Walworth representatives. Each seminar uses slides, pictures, prints, blackboard diagrams, actual valves and component parts. Program is now supplemented by a special, mobile valve maintenance unit which also instructs customer personnel in proper valve operation.

Core Laboratories, Inc., Dallas, has begun a new service for the petroleum industry. Called "computerized production accounting," service offers expanded facilities of Core Lab's electronic data processing and computing center to the industry. System adapts to virtually any continuous production data-handling requirement with economy, speed, and accuracy.

Bovaird Supply Company has become a stocking distributor of Gardner-Denver mud pumps and other petroleum equipment. Company is authorized to distribute equipment in stores located in Oklahoma, Kansas, Texas, New Mexico, Louisiana, and Illinois.

Another benefit of an Oakite ECP*



Soak-clean clogged pump in 30 minutes

Clean chemically wherever you can—that's a basic principle of Oakite ECP, the Engineered Cleaning Program that saves you time, work, money.

For example, see how fast ECP restores that fouled bottom-hole pump. In minutes, you soak away surface grease and mud with the recommended Oakite solution. Another short soak in an Oakite descalant liquidates deep-seated interior rust obstructions plus gyp and lime. Half an hour's time and the restored unit is ready for service.

****OAKITE ECP is a detailed Engineered Cleaning Program developed to fit your particular operation under the experienced supervision of your local Oakite man. ECP covers all your cleaning needs.***

For more details write Oakite Products, Inc., 47A Rector Street, New York 6, N. Y.

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over 50 Est. 1909 SCIENCE years' leadership in industrial cleaning

What's doing in DRILLING

Jersey Researchers Reveal Three Drilling Developments

Three significant developments in oil well drilling were shown publicly for the first time recently at Jersey Production Research Company's new laboratory in Tulsa which is devoted entirely to drilling research.

High-pressure chamber to simulate bottom-hole drilling conditions enables various bottom-hole pressures to be simulated so that bit tooth action on rock can be more carefully studied with the aid of a high-speed camera that photographs the action.

Goal of project is to determine how drill bits penetrate rocks under conditions encountered at the bottom of the hole. High speed movies obtained show graphically how the strength of rock increases with pressures applied to 15,000 psi.

Chamber simulates fluid pressure in the hole, fluid pressure in the formation, and the weight of the earth above section being drilled. A single chisel, simulating one tooth of a bit, is dropped on the formation to measure and record loads, displacements, and volume of rock removed.

Down-hole recorder may lead to improvements in drill bits and manner in which they are used through providing reliable down-hole engineering data.

Recorder system includes an eight-channel tape recorder which is only four inches in diameter. Tool measures weight and torque on the bit; vertical, angular and lateral accelerations; pressure inside and outside the drill pipe; and temperature. Strain gages electrically record the measurements.

Transistorized electronics package located in center of tool amplifies signals from strain gages.

Ten tests at shallow depths have demonstrated that the tool is field-worthy, Jersey researchers report.

Hydraulic wall-anchored drill collar applies high bit weight without use of conventional drill collars in harder formations.

Developed by Jersey Research, tool consists of several pistons rotating inside a steel case which is anchored to the wall of the hole by special diaphragm-type anchor shoes. Pressure drop across the bit expands the shoes against the wall of the hole. Pistons, which are staged in series, also utilize the pressure drop across a conventional jet bit to apply the necessary hydraulic loading. Top of each piston is exposed to the high-pressure drilling fluid inside the drill pipe, while the under side of each piston is vented to the lower pressure fluid in the annulus.

Researchers report success in a series of shallow drilling tests in West Texas. Present tool must be reset by raising drill stem after drilling two feet, however, a tool currently being developed will reset automatically.

Special Rockets Devised For Siting Offshore Well

Specially-designed rockets served as a sight-in guide in a night-time visual survey of location on Shell Oil Company wildcat 31 miles south of Galveston, Texas.

This first in offshore operations helped surveyors get their bearing to determine location of underwater well site. Site chosen in Federal Block OCS-288 is under 65 ft of water on the 5760-acre tract.

Due to curvature of the earth, the site is not visible from land. This ruled out making a daytime survey.

To make the night location, two survey teams were stationed at different "known" points along the coast. After first determining the geodetic position of a specific point on another offshore platform in the Gulf, a third team was stationed aboard this platform.

Then a boat with a rocket-firing crew was dispatched to well location, as previously determined electronically by a radar system.

Rockets that reached 700-ft in air, compared to ordinary 200 to 250 ft rockets used, were fired and simultaneous readings on flares were taken by survey teams. Each parachute suspended-flare burned about 30 seconds.

This satisfied a U.S. Bureau of Mines requirement for a geodetic position of the well site.

Servicing Company Appoints Full-Time Safety Engineer

Chris Well Servicing Company, Ltd. has become the first oil well servicing contractor to install a safety program headed by a full-time safety engineer. Barry Turner, formerly assistant safety engineer for Sohio Petroleum Company, has been named to head the program.

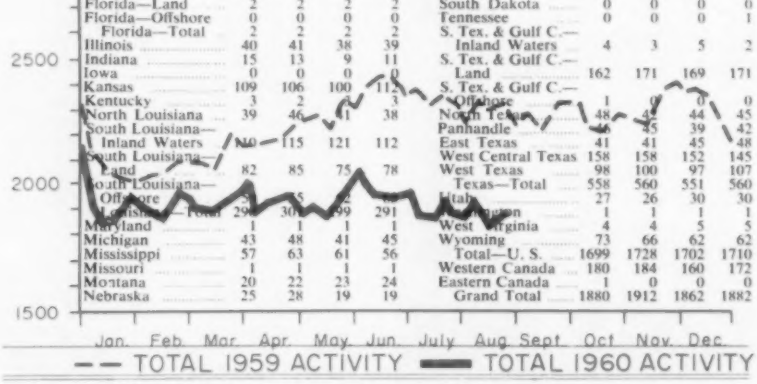
Safety contest units and individuals will compete for awards, Ray E. Christian, company president, said. A plaque will be awarded to each unit which is successful in eliminating lost time accidents.

These plaques and individual awards will be presented at a series of safety dinners for men of the winning units and their wives. Weekly safety meetings have been initiated and systematic safety inspection and accident investigation procedures have been installed.

Rotary Rigs Operating in Oil Fields of United States and Canada

As reported to American Association of Oil Well Drilling Contractors by Hughes Tool Company

	Aug. 1	Aug. 8	Aug. 15	Aug. 22
Alabama	4	4	4	4
Alaska	7	7	7	7
Arkansas	12	12	13	13
Arizona	1	1	1	1
California—Land	76	76	81	81
California—Offshore	2	2	2	1
Calif.—Total	78	78	83	82
Colorado	39	36	37	44
Florida—Land	2	2	2	2
Florida—Offshore	0	0	0	0
Florida—Total	2	2	2	2
Illinois	40	41	38	39
Indiana	15	13	9	11
Iowa	0	0	0	0
Kansas	109	106	100	112
Kentucky	3	2	1	3
North Louisiana	39	46	41	38
South Louisiana—Inland Waters	110	115	121	112
South Louisiana—Land	82	85	75	78
South Louisiana—Offshore	25	25	23	23
Louisiana—Total	296	305	299	291
Maryland	1	1	1	1
Michigan	43	48	41	45
Mississippi	57	63	61	56
Missouri	1	1	1	1
Montana	20	22	23	24
Nebraska	25	28	19	19
Nevada	0	0	0	0
New Mexico	110	105	112	112
New York	0	0	0	0
North Dakota	13	16	16	14
Ohio	5	5	6	3
Oklahoma	150	165	163	157
Oregon	1	1	1	1
Pennsylvania	10	13	13	9
South Dakota	0	0	0	0
Tennessee	0	0	0	1
S. Tex. & Gulf C.—Inland Waters	4	3	5	2
S. Tex. & Gulf C.—Land	162	171	169	171
S. Tex. & Gulf C.—Offshore	1	0	0	0
North Texas	48	47	44	45
Panhandle	46	45	39	42
East Texas	41	41	45	48
West Central Texas	158	158	152	145
West Texas	98	100	97	107
Texas—Total	558	560	551	560
Utah	27	26	30	30
Washington	1	1	1	1
West Virginia	4	4	5	5
Wyoming	73	66	62	62
Total—U. S.	1699	1728	1702	1710
Western Canada	180	184	160	172
Eastern Canada	1	0	0	0
Grand Total	1880	1912	1862	1882



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...YOU'VE ALREADY SAVED HUNDREDS OF DOLLARS!

When you have a small remedial job involving just a few sacks of cementitious material, call your Halliburton Dump Bailer man and watch the savings mount up. SAVE on equipment — no big rental bills on unnecessary pump trucks! SAVE on downtime — no strings of drill pipe or tubing are needed with the wire-line-run bailer! SAVE on material — use and pay for only the amount you need!

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CAL-SEAL . . . a quick setting, super-strength gypsum cement that expands as it sets for a tighter plug.

HYDROMITE . . . a waterproof plastic-gypsum cement used extensively for plugging off bottom hole water in producing wells.

RESIN CEMENT . . . penetrates surrounding formation and sets to form an impermeable seal and strong plug.

HYDRO-LOK (PC-11) . . . a plastic slurry with fluid loss control properties. Setting time of resin phase is accelerated by water contact in the formation.

With these products, plus the long experience your Halliburton man has had with them . . . *and* the special tools Halliburton has developed — like the DB Bridging Basket and Limit Plug, you can expect *top performance* every time you specify Halliburton Dump Bailer Service.

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275 SERVICE CENTERS . . .
JUST MINUTES AWAY
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Malleable Aluminum Particles Tested For Fracturing Wells

Using malleable aluminum particles in an effort to achieve high fracture conductivities, Atlantic Refining Company and Reynolds Metals Company have developed technique called Frac-Shot and conducted tests in eleven wells.

The development has proved conclusively that wells fractured with the pellets can increase output up to 250% or more, L. R. Kern, director of Atlantic's fracturing research said. "Because of the many factors present in highly permeable formations, fractures with sand often resulted in a crushing of the propping agent or a sinking of the agent into the formation," Kern said.

"Aluminum particles, on the other hand, when properly used will resist both problems. Due to aluminum's innate malleable property, it will deform slightly rather than be crushed. Also, the aluminum deformation results in a greater particle-bearing area against the formation wall. This reduces the stress on the particle and its penetration into the formation," Kern continued.

The eleven wells test fractured by Atlantic were in Texas, Oklahoma, Wyoming, Louisiana, and Kansas.

Kern outlined these results for the tests:

1. One gas well located in the Wilcox formation near Freer, Texas increased output from 130 to 700 Mcf per day. Predicted conventional fracturing results would have yielded only 260 Mcf per day.

2. A well in Hoxbar formation, near Duncan, Oklahoma, increased output from four bbl per day to 15. Previous sand fractures in the same field failed consistently to increase production.

Four leading well-fracturing companies will offer Frac-Shot service.

Over 1100 field installations
. . . less than 2% maintenance!

OIL WELL M&T SERVICE
FRICTIONAL TUBING ANCHOR
U.S. Patent No. 2,874,783

- Smooth gripping members hydraulically actuated
- No slips to replace
- Completely automatic
- Calibrated holding power
- No bleeder valve required
- Large by-pass area
- O-ring fluid seal
- Simple construction, minimum maintenance
- Installed above pump; automatically "sets," holding tubing in natural tension
- No drag on casing going in hole or coming out unless tubing is pulled "wet"
- Can safely be installed in perforated pipe

Compensates both up and down

Complete range of sizes for 4½" to 11¾" API Casing. Write for complete information.

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P.T.C. . . . The original Paraffin Treating Chemical. Holds paraffin in suspension from formation to refinery.
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CORROSION INHIBITOR CI-123 . . . Designed especially for control of oil field corrosion problems.
GYP and SCALE TREATMENT GS-20 . . . Effective on these types of carbonates and sulphates: calcium, strontium, barium and magnesium.

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BBM Drilling Company Moves Offices To Midland

General offices of BBM Drilling Company have been moved from Houston to Midland. Company had been headquartered in Houston since it was organized in 1949.

Frank J. Whitley, president, will continue to make his home in Houston, but he will spend considerable time in the Midland office. For the next few months, George R. Bixler, land manager, will divide his time between Midland and Houston.

John Ed Cooper is vice president and general manager of the BBM organization, which does contract drilling and drilling for its own account and also has producing properties and undeveloped leases in West Texas, New Mexico, South Texas, and Louisiana.

Company operates eight rotary drilling rigs. All of them are in the Permian Basin of West Texas, and the company has maintained division offices in Midland since starting operations.

Frank Dameron, chief geologist, A. K. Haggard, drilling and production superintendent, and M. L. Masterson, drilling and production engineer, were located in Midland before the general offices were moved there.

Other executives moving to Midland are R. I. Sandlin, secretary-treasurer and purchasing agent, H. E. Orwig, assistant treasurer and office manager, and R. E. Warner, chief accountant.

BBM now has more than 70 full-time executives, supervisors, and employees in Midland.

Tulane Plans Discussion Of Tidelands Problems

A discussion of major mineral and tidelands problems will be discussed in fifth annual program on "Mineral and Tidelands Law", which will be presented December 9 in New Orleans. Cosponsored by the Tulane University School of Law and American Association of Oilwell Drilling Contractors, program is open to attorneys, oil and insurance company representatives, and other interested persons.

Topics discussed by authorities will include liability trends and developments from the legal and insurance standpoints; changing shoreline of Louisiana; problems related to forced unitization; and regulation of the gas industry.

Contractor Ships New Rig For Drilling in Brazil

Brantly Drilling Company (International), Inc. of Midland has loaded a new rotary drilling rig on a freighter at Houston for shipment to Brazil. Rig will drill for Petrobras, governmental oil monopoly, and it will be the second Brantly rig in the South American country.

New rig will be used in a development program on a 7000-ft deep pay in Bahia, M. M. Brantly, president of the company, said.

Six Americans will supervise operation of Brantly's No. 2 rig.

Air-Drilling Specialists Head International Firm

C. V. Helm

W. A. Triest

Two air-drilling specialists head up the newly-formed International Air Drilling Company, with headquarters in Fort Worth, Texas, USA. C. V. Helm, formerly operations manager for The Western Company, is president and William A. Triest, of Gardner-Denver Company's air and gas drilling group, is head of the company's global engineering sales activities. European offices are located at 47 Ave. de Floreal, Brussels 18, Belgium.

New firm will offer to the world the benefit of advanced technology and engineering services in air and gas drilling, including compressor equipment, chemical injection, manifolding design, and well-head equipment. Intairdril will provide engineering studies for air drilling of prospective locations; planning for air, gas, mist, or aerated liquids drilling; equipment specifications and fabrication supervision; chemical additives; and air drilling specialists for consultation and supervision on location.

Oil Scouts Group Reports 2274 Rigs Operating in U.S.

Rigs operating in United States total 1698 rotary and 576 cable tool according to International Oil Scouts Association report to American Association of Oilwell Drilling Contractors for August 26. Combined total amounts to 2274 rigs and includes those from the rigging up to tearing down stages.

Research Lab Developing Unit For Running Casing

Developing a drillable combination float shoe and bit, liner hanger and setting tool which will enable a liner to be run to the bottom and simultaneously reciprocated, rotated, or both

SECONDARY RECOVERY

PETROLEUM ENGINEERS
STEPHENS ENGINEERING
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Water Flooding Gas Repressuring
EVALUATION CORE ANALYSIS
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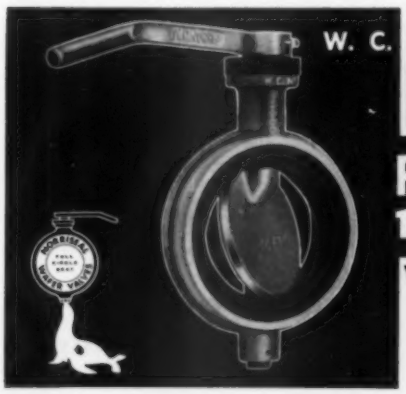

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Field Tested and Approved
150 psi working pressure
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The
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DS* TUBING JOINT
Has Proved
Its Superiority as to
ECONOMY • CLEARANCE
PRESSURE HOLDING ABILITY
In Over
3,000,000 FT. OF TUBING

This streamlined integral connection is designed for applications where clearance is a problem in moderate depth wells. Its tremendous acceptance has resulted from the effectiveness of the Teflon† seal to hold pressures, its balanced streamlined design, and its reasonable cost.

Complete technical data and costs are available from the H-G salesman, or direct from the company.

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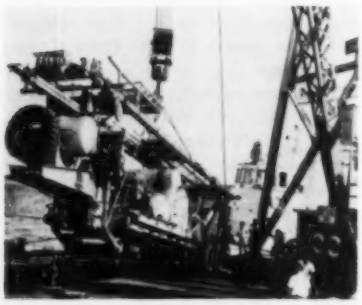
Oklahoma City, Okla. Tulsa, Okla.

*Patent Pending
†Registered trademark of E. I. du Pont de Nemours and Co.

stands as objective of Project One Thousand.

Underway at Southwest Research Institute in San Antonio, Texas, designers intend liner hanger and setting tool coacting with it to withstand more tension, compression, torsion, or any combination of these factors than either the liner or run-in string would ordinarily.

Liner hanger consists of slip to hang liner in tension from the casing, a packer to seal between the liner and the casing, and a release joint which will release the resetting tool from the liner when desired. Setting tool cannot be released accidentally from the liner.



On arrival in Mombasa, floating crane unloads 35-ton portable drilling rig. BP-Shell Petroleum Development Company of Kenya will drill a series of medium-depth stratigraphic holes in Lamu area with rig to provide geological information complementing seismic work.

Santa Monica Voters Reject Offshore Drilling

In a special election recently, voters of Santa Monica, California, rejected a proposal to permit offshore oil drilling. Vote was 12,149 against and 6360 in favor. A similar proposal was defeated in 1954 by a 4 to 1 margin.

Mobil Oil Company has a contract with the city to explore the offshore lands and produce oil under the tidelands controlled by Santa Monica. Company cannot proceed with drilling activities until the voters revoke or modify a city ordinance against drilling.

Santa Monica would receive 35% of gross oil revenues should the drilling ban be repealed.

Fifth Anniversary
RIG LOCATOR
included in this
Drilling Progress Issue

"We deliver too"

What's so special about the huge fractionating tower shown here? It is one more example of how Sun Ship builds and delivers heavy industrial equipment on barges or sea-going vessels, with careful attention to such requirements as safety and on-time schedule.

Whether it's a fractionating tower or key structural part for industry, transporting big items by water or by rail is strictly routine for Sun Ship, for we build and deliver what's needed in many fields. If you have a machinery or heavy equipment problem, write to us about it.

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VALVES

performance makes the world of difference

POWELL PETROLEUM VALVES

Powell valves are performance-proven with 100 years of service to the oil industry. Powell offers valves in the greatest variety of sizes, designs, pressures, and metals to handle almost *every* flow control requirement of *every* industry. Contact your nearest Powell distributor. Or write to us. Our engineers and metallurgists are at your service to solve your valve problems!

Fig. 559—Large iron body bronze mounted swing check valve for 125 pounds W.P. Bolted flanged cap. Regrindable, renewable bronze seat and disc.

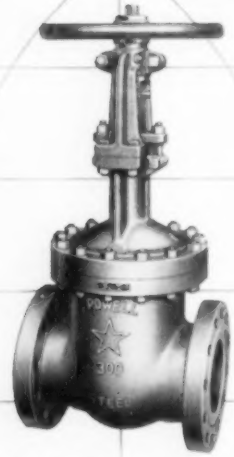

Fig. 3003—Flanged end steel gate valve for 300 pounds W.P. Outside screw rising stem and yoke.

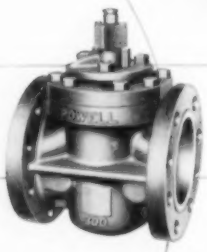

Fig. 3059—Steel lubricated plug valve. ASA 300 pounds. Bolted gland type. Also available with screwed ends—Fig. 3058.

THE WM. POWELL COMPANY • DEPENDABLE VALVES SINCE 1846 • CINCINNATI 22, OHIO

New B&W REFRACTORIES FOR THE PETROCHEMICAL INDUSTRY

B&W's line of refractories has been enlarged by the addition of new heavy duty firebrick and new ramming mixes. These new products, now offered after many years of developmental and field experience, are specifically designed for superior service in carbon black furnaces, butadiene reactors, reforming furnaces and vessels and other typical equipment used in petrochemical processing.

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HIGH BURNED SUPER DUTY FIREBRICK

Fusion point 3220 F. This brick offers an excellent balance of properties to assure superior service. It provides approximately 5% more alumina content and lower total impurities than competitive brick. It has excellent spalling resistance.

KAO 60

60% ALUMINA FIREBRICK

Fusion point 3250 F. Provides higher hot load strength than any competitive brick. Spalling loss is only 1%

KAO 70

70% ALUMINA FIREBRICK

Very low total impurities provide long life. Spall loss of only 2%.

RAMMING MIXES

★

MULRAM E

Use limit 3200 F. Alumina content—80%. This new ramming mix with extremely low permeability provides exceptional resistance to slag or molten metal penetration. High strength provides good erosion resistance.

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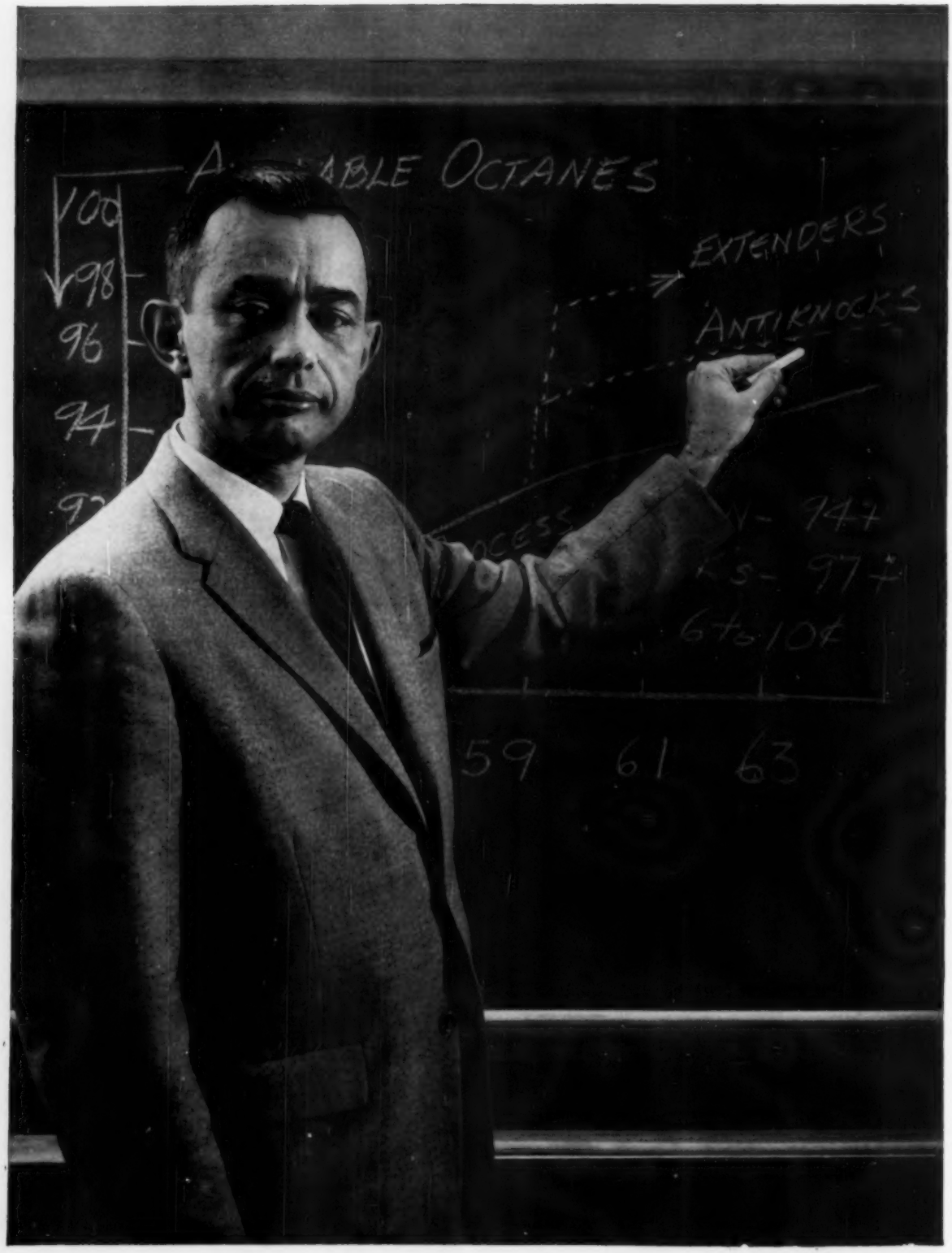
"Never before have the octanes offered



by additives been so important..."

T. W. Warren, Ethyl's Director of Refinery Technology, discusses how you can save by using the "additive octane" route.

"ADDITIVE OCTANES" are important in planning the most economical means for producing fuels to satisfy today's cars. And now is the time to study new additive potentials as you plan for the future. Antiknocks and extenders can supplement existing processing flexibility and provide a well protected but economical timetable for your product needs.

Additives an economical buy

However you control your quality—on a Research, Motor or Road octane basis—*antiknocks are the least expensive way to increase quality on a cost per octane basis* in nearly every refinery situation.

Furthermore, if lead is used to increase antiknock quality as measured by Research method, there is a substantial Road octane bonus as measured by current rating methods. Only antiknocks give this Road octane "extra."

Additives versus capital investment

Antiknocks have long provided refiners with the ability to meet needed octane increases almost overnight. That protection is greater now than in the past.

For the foreseeable future, the refining industry can meet all octane requirements with currently installed equipment and the additives now available. The need for capital investment may be delayed indefinitely, since "additive octanes" will provide a well-protected but economical cushion if there is a need for octane increases.

For premium grade fuels, antiknocks and extenders already available and others being developed—together with increases in octane available from installed processing equipment—assure you of ample quality for many years to come.

For regular grade fuels, the use of maximum TEL offers even greater protection. Additional octane quality is available from Ethyl's new antiknock compound, Motor 33 Mix. To this can be added quality improvement available from existing processing.

What about the future?

Research continues in the "additive octane" field. The future is certain to provide even greater choice and flexibility for the refiner.

For example, antiknocks are now being developed which may be used to great advantage in special applications to improve road performance. Several TEL extenders are also being studied. Some of these will eventually be commercially available.

Before you consider building new process equipment, we invite you to discuss with our technologists how "additive octanes" can be your best buy. Such a discussion may lead you to postpone additional capital investment in equipment for a long time. Call or write your Ethyl Representative to get all the details.

ETHYL ANTIKNOCK COMPOUND — ETHYL CORPORATION

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HELPFUL WATER CONDITIONING DATA FROM BETZ

PRETREATMENT FOR EFFECTIVE

■ Rapid film formation by pretreatment can vastly improve cooling water corrosion control. The benefits are many and the added costs are negligible.

THE ADVANCES MADE in the control of corrosion in open recirculating cooling water systems over the past decade have been phenomenal. The Dianodic methods[1] for corrosion control are capable of decreasing the corrosion rate of steel to 1 mil per year or less with the pitting function totally prevented or definitely stifled. Excellent protection is secured with treatment concentrations generally in the range of 30 to 100 ppm, depending on operating conditions and water characteristics. Because steel can be protected economically many of the newly designed plants include all-steel heat exchangers in place of the more costly and more commonly used Admiralty tubed heat exchangers. The cost of all-steel heat exchangers is approximately 60% of the cost of heat exchangers constructed with Admiralty tubes. Under these conditions the capital investment for a new plant is considerably less when steel is used.

However, the design engineer should be cognizant of all factors that have a bearing on the service life of steel tubed heat exchangers. The experiences of one plant designed with all-steel heat exchangers will illustrate several of the precautions that are necessary if the expected service life is to be secured. Shortly after this new plant went into operation, it was found that pressure drops across many of the heat exchangers were greater than anticipated. Examinations of the heat exchangers revealed that heavy tuberculation was present in the steel tubes and in the water boxes. Some of the tubes were blocked with tubercules that had broken free from other locations. It was evident that the handling of the bundles during construction of the plant permitted corrosion to start. The pressure of other work attendant with start-up did not allow sufficient time for initial cleaning of the heat exchangers for removal of debris, grease, and corrosion products that had accumulated during construction. No pretreatment of the heat exchangers was employed and the intermittent operation of the system permitted frequent periods of inadequate inhibitor concentrations so that corrosion progressed at a rapid rate.

A marked difference in the care of handling steel tubed heat exchangers compared to handling Admiralty tubed heat exchangers is evident from this and similar experiences. The corrosion rate of steel under these adverse conditions is many times greater than the corrosion of Admiralty and the quantity of corrosion products produced is proportionally greater. When steel tubed heat exchangers are employed, it is essential that care be exercised in the initial handling of the bundles to avoid corrosion during construction and initial start-up. It is mandatory to clean steel bundles and to pretreat them to render the metal surfaces passive.

Pretreatment

Most methods of corrosion control are based on forming a film that acts as a barrier to stifle corrosion. The rate at which the film or barrier forms will largely determine the effectiveness of the treatment. Materials that do not form films rapidly will permit corrosion to take place and the result will be incomplete film formation and continued corrosion. The rate at which the film forms is related to the inhibitor concentration.

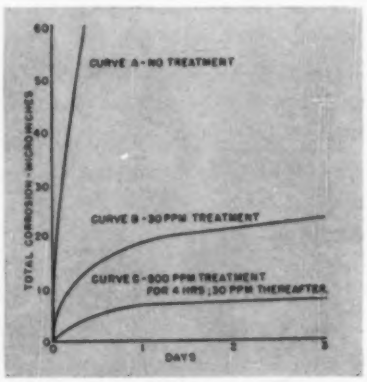

Figure 1

The function of pretreatment is primarily to permit rapid film formation to stifle the corrosion reaction immediately by formation of a uniform impervious film. Under these conditions the low treatment levels will maintain the film intact and avoid the accumulation of corrosion products.

Reference to Figure 1, Curve A, shows the high initial corrosion rate of steel when exposed to Philadelphia tap water, fortified with 500 ppm of chloride, and at a temperature of 120 F. The application of 30 ppm of Zinc-Dianodic markedly decreases the rate of corrosion (to less than 1.5 mils per year at the end of 3 days). However, if the steel is first pretreated for rapid film formation with a treatment concentration of 500 ppm of Zinc-Dianodic for only 4 hours and thereafter treated with 30 ppm of Zinc-Dianodic an even greater reduction in the initial corrosion rate as well as the over-all corrosion rate results, as shown by Curve C.

The data contained in Figure 2, demonstrate the superior qualities of the film formed by 500 ppm of Zinc-Dianodic compared to 5000 ppm of chromate. Pretreatment with 5000 ppm of chromate for 2 hours permitted a 50% reduction in weight loss and a corresponding reduction in the amount of corrosion products that accumulate. However, pretreatment with 500 ppm of Zinc-Dianodic for 2 hours permitted more than an 80% reduction in weight loss and a negligible accumulation of corrosion products.

The low treatment levels normally used for corrosion control in open recirculating systems should be viewed as the quantities required to maintain the film intact and to heal the slight breaks that may occur from minor variations in environment. Whenever any serious changes in environment occur that cause destruction of the film, corrosion products can accumulate before the film is re-established by the low treatment levels. Under these conditions, in order to secure maximum corrosion protection and to minimize accumulation of corrosion products, treatment levels should be increased to re-establish the protective film as rapidly as possible.

Pretreatment of steel heat exchangers is required . . .

. . . for all new bundles
. . . whenever the exchangers are acid cleaned
. . . whenever low pH is encountered
. . . whenever serious process leakage occurs
. . . immediately following start-up after inspections.

Care of Steel Exchangers

Initial Treatment

The care of new steel heat exchangers should start with the writing of the

(1) Dianodic is a registered trademark. The methods are covered by U. S. Patents 2,711,391; 2,900,222; 2,872,281; 2,848,299.

specifications. The design engineer should include as part of the specifications, a requirement that the units be delivered free of debris, grease and other foreign matter that may initiate corrosion, and that the units be protected from the weather during transit and prior to installation. As soon as possible after installation, and prior to placing the system in full operation, pretreatment should be applied to the circulating water to permit rapid film formation. A procedure of this type will avoid excessive pressure drops and assure maximum protection of the units as well as materially aid in achieving the anticipated service life of an all-steel system.

Other Factors

Once the film is properly formed, the normal treatment levels will serve to maintain the film and prevent corrosion under normal operating conditions. However, there are a number of factors that can destroy the film to such a degree that higher than normal treatment levels will be required to re-establish the film rapidly. For example, when an individual heat exchanger is acid cleaned, the film will be completely destroyed. Acid cleaning will leave the steel surfaces in a very active state and the initial corrosion rate will be very high. The normal treatment levels usually will not permit sufficiently rapid re-establishment of the film. Therefore, following acid cleaning and flushing, the unit should be pretreated.

The modern day corrosion inhibitors function best in a pH range of 6.0-7.0. This same pH range permits maximum protection to tower wood and is usually the pH range required to avoid calcium deposits. Therefore, acid treatment of the circulating water to control pH is a common practice. In the great majority of these systems excellent control of pH is maintained. On occasion, however, low pH values may develop. If low pH is permitted for any extended period of time, partial or complete destruction of the protective film may occur. When this occurs, treatment levels should be increased to re-establish the film as soon as possible.

In other systems, process leakage may introduce hydrogen sulfide and mercaptans. This type contamination will have an adverse effect on most films. Also, leakage of this type usually produces a drop in pH as well. Until such time that the leakage can be corrected the system should be blown down heavily. If it is established that a particular heat exchanger is a chronic offender, it should be equipped with blowdown facilities so that as much of the blowdown as possible is taken from the offending heat exchanger. Following correction of the leak, treatment levels should be increased to rapidly re-establish the film.

The periodic inspections required for most systems will produce conditions during start-up that may increase the initial corrosion rate. For example, brushing or manual cleaning of the water boxes or other parts of the heat exchanger may partially or totally remove the protective film. Debris and migratory corrosion products may settle at various points in the system. These and many other factors will create conditions conducive to corrosion. Pretreatment by the use of higher than normal treatment levels during start-up will assure rapid repair of the protective film and minimize the accumulation of corrosion products.

The precautions outlined above will be instrumental in achieving maximum service life from all-steel heat exchanger systems.

CORROSION CONTROL

Specimen	Pretreatment (2 hrs.)	Loss-mgs. (24 hrs.)
A	None	36
B	5000 ppm chromate	18
C	500 ppm Zn-Dianodic	6

Conditions—Philadelphia tap water fortified with 500 ppm chloride. Temperature 120 F. 24 hour exposure in 8 ppm of Zinc-Dianodic after pretreatment as indicated.

Figure 2

General Application

While much attention has been focused on the use of pretreatment for all-steel systems because of the higher corrosion rates that can occur, the principles of pretreatment have application to and will prove beneficial for cooling water systems in general. It is true that the initial corrosion rates for Admiralty tubes or tubes of copper alloys in general are materially lower than for steel, and therefore the effects of these less voluminous corrosion products are not as pronounced. However, where Admiralty tubed heat exchangers are employed the systems are bimetallic since the shells and water boxes are constructed of steel. While the Admiralty heat exchanger tubes are not adversely affected, the steel components of these units do undergo an initially high corrosion rate and produce voluminous corrosion products that interfere with proper and complete film formation. The application of the principles of pretreatment for rapid film formation, followed by the use of normal treatment levels for film maintenance will prove of benefit in minimizing corrosion of the steel parts of the system. In general, improved heat transfer, longer service life and less plant maintenance are the benefits that will be secured.

The Dianodic methods developed by Betz are the most effective corrosion control treatments for recirculating cooling water systems. Their effectiveness is due to the ability to form protective films rapidly and to maintain these films with relatively low treatment levels. The Betz Engineer in your area will be pleased to discuss corrosion control and the application of pretreatment to handle your cooling water problems. Why not contact him *today?*

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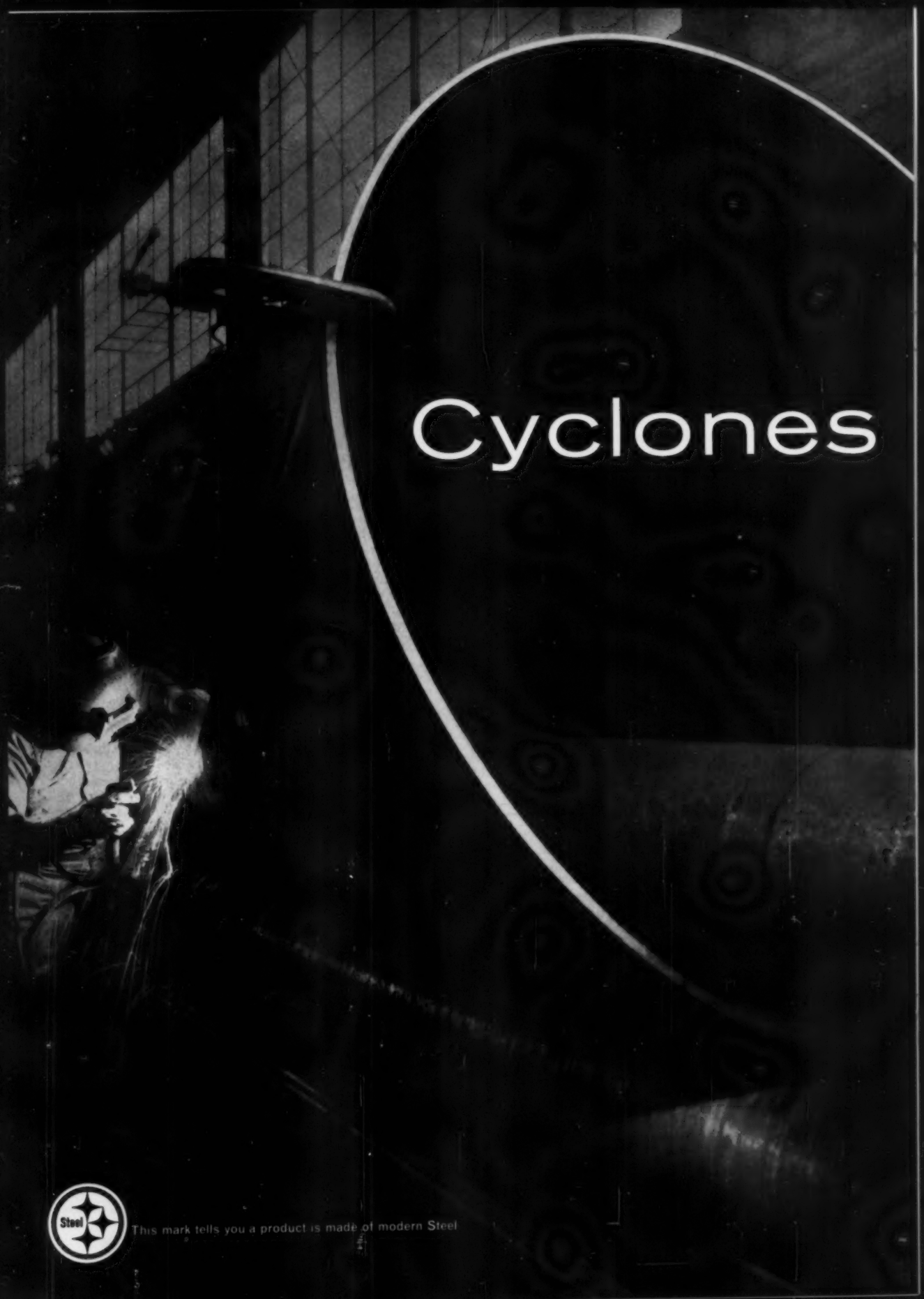
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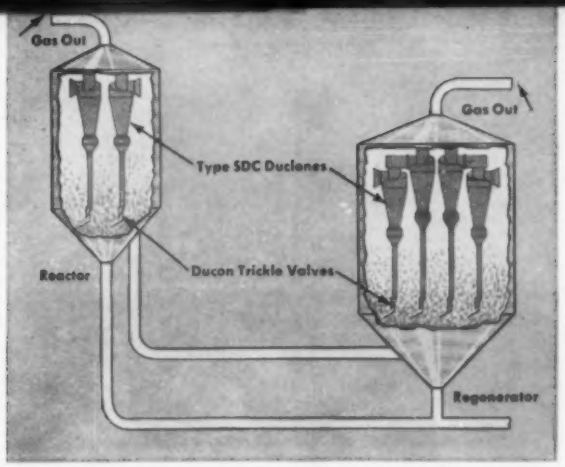

General arrangement of Ducon cyclones in the reactor and regenerator of a fluid catalytic cracking unit. Stainless cyclone collectors keep catalyst loss to a minimum. "Duclone" is a registered trademark of the Ducon Co.

start here...

. . . and end up in fluid bed cat crackers where they circulate up to 60 tons of catalyst every minute. At $400 to $500 a ton, lost catalyst can put a lot of red ink into a refinery's operating budget. Breakdowns cost from $20,000 to $50,000 a day. That's why it is so important to design with the right material from the start: USS Stainless Steel.

Stainless Steel cyclones used for catalyst recovery are subjected to extreme heat and erosion. Temperatures in a regenerator unit can go as high as 1400° F. At high temperatures elemental sulfur corrosion would eat out most materials in nothing flat. Not Stainless. And Stainless Steel retains its strength at high temperatures. Stainless cyclones aren't in danger of changing shape which could cause catalyst loss.

Nothing equals Stainless Steel as a solution to the many complex problems in a refinery. It has outstanding corrosion resistance for a wide range of reagents, excellent high temperature strength. Its smooth, dense surface won't harbor contamination, is easy to clean. Above all, USS Stainless Steel promises long life and low maintenance. Order USS Stainless Steel through your USS representative or your local Steel Service Center.

If you are interested in more information about these Stainless Steel cyclones, wire or write U.S. Steel, Room 6104, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

USS is a registered trademark

Left, welder completes longitudinal seam of one segment of the cyclone at The Ducon Company's Mineola, N.Y. plant. **Below,** stainless steel cone is removed from the forming rolls.

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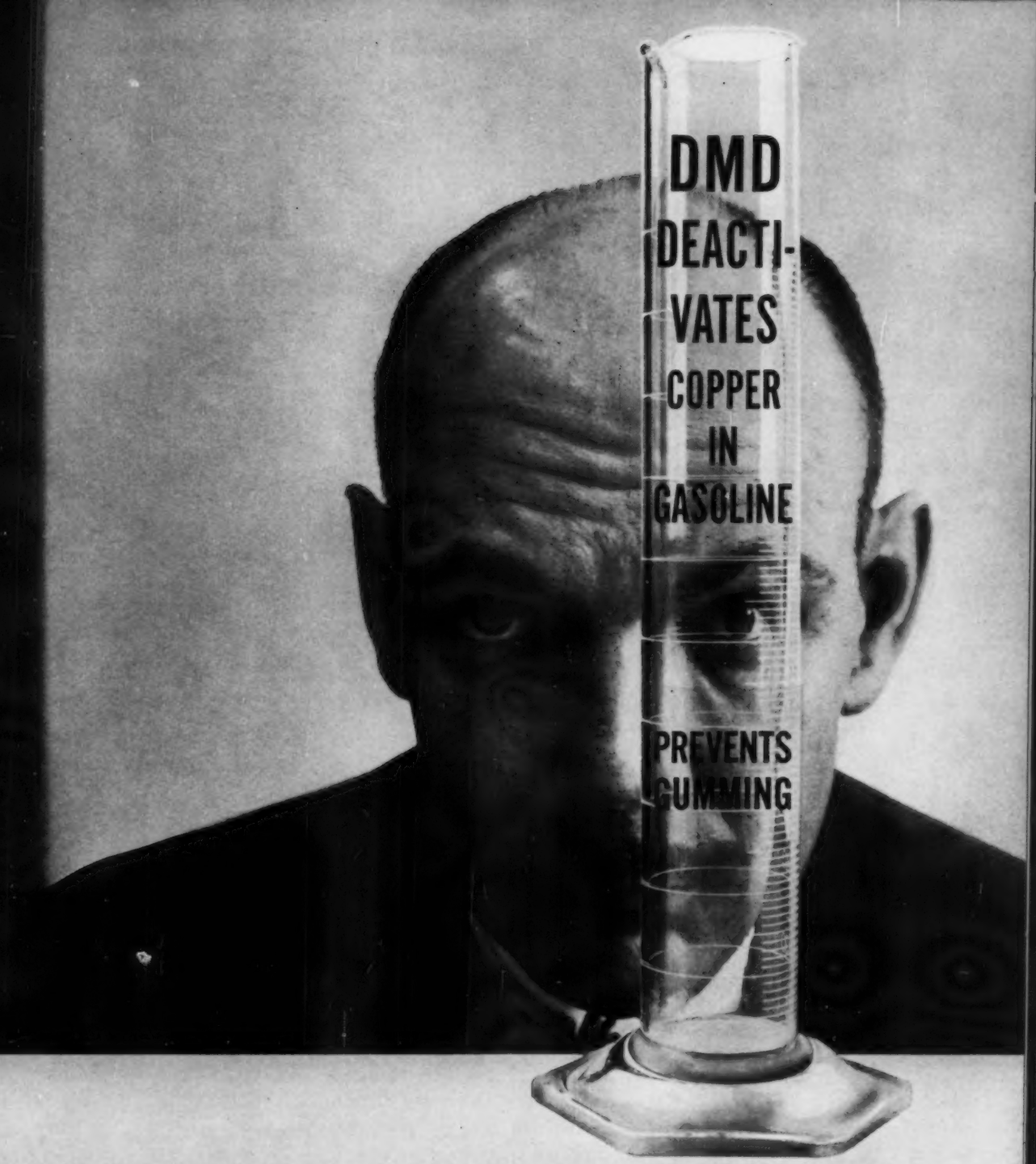

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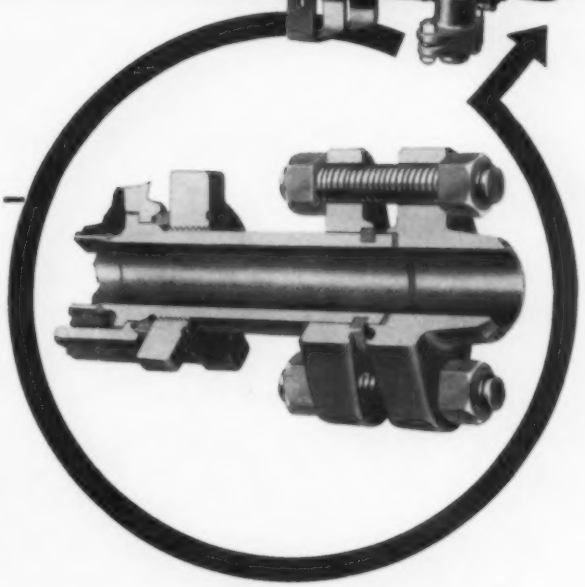

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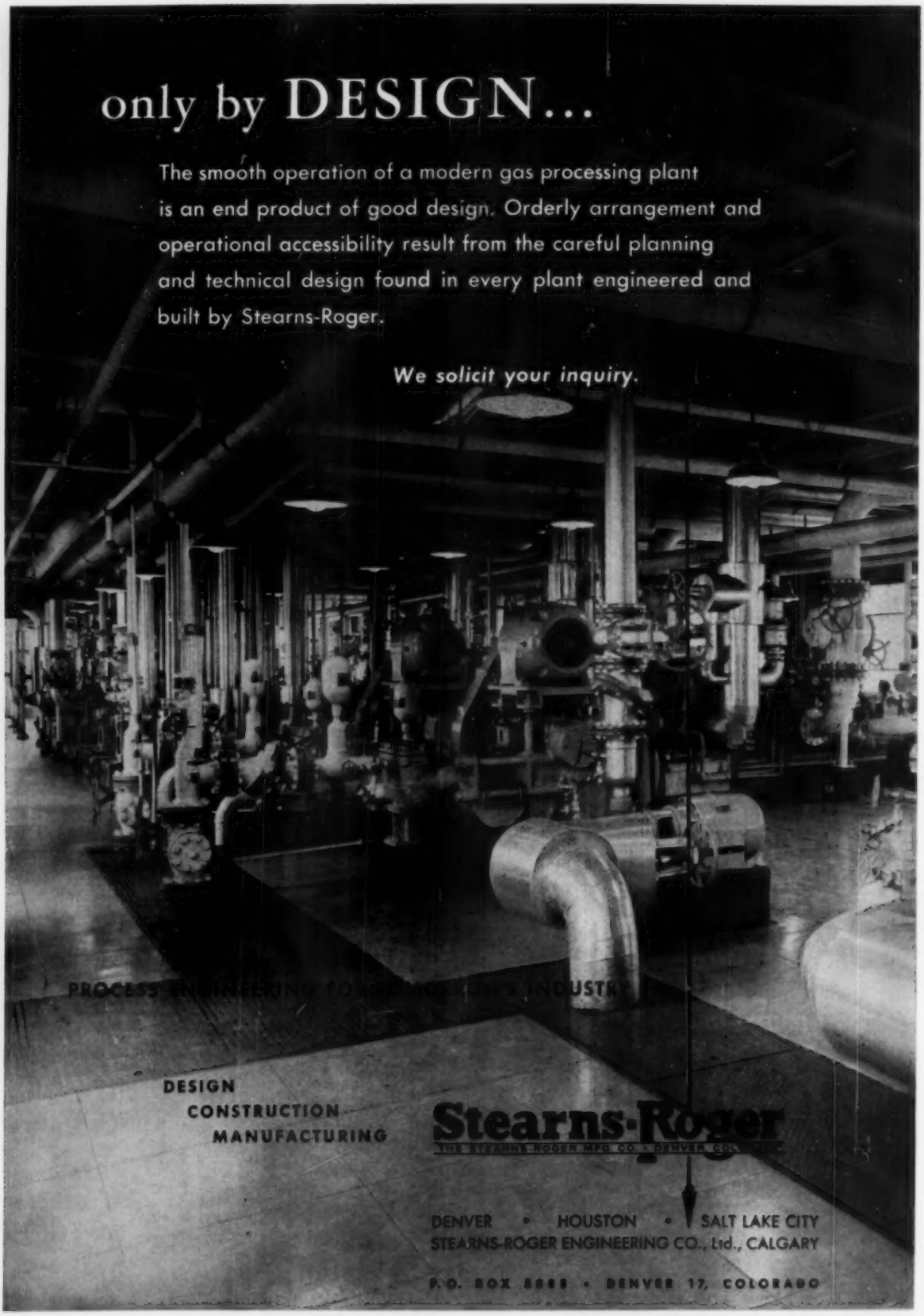
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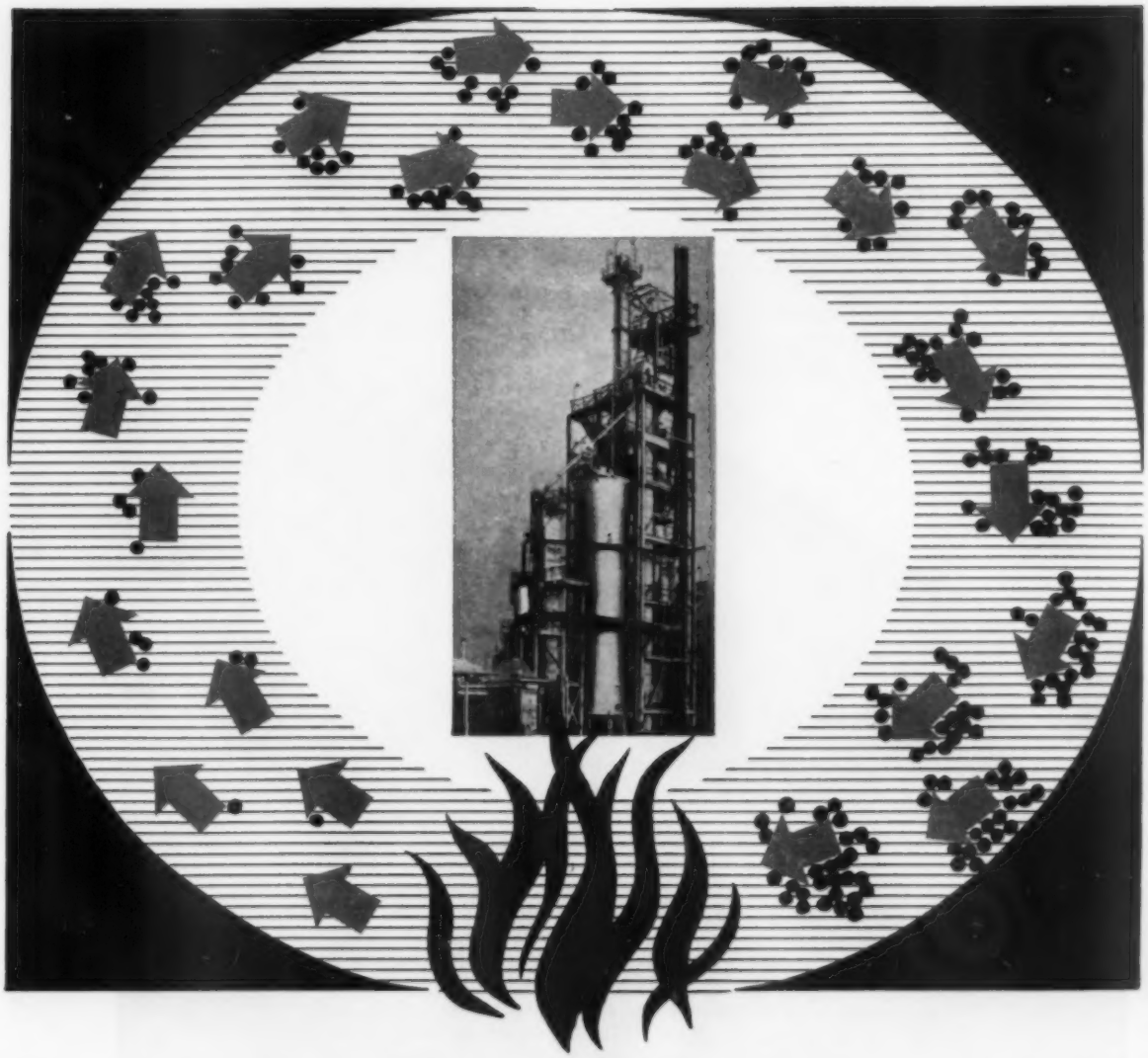

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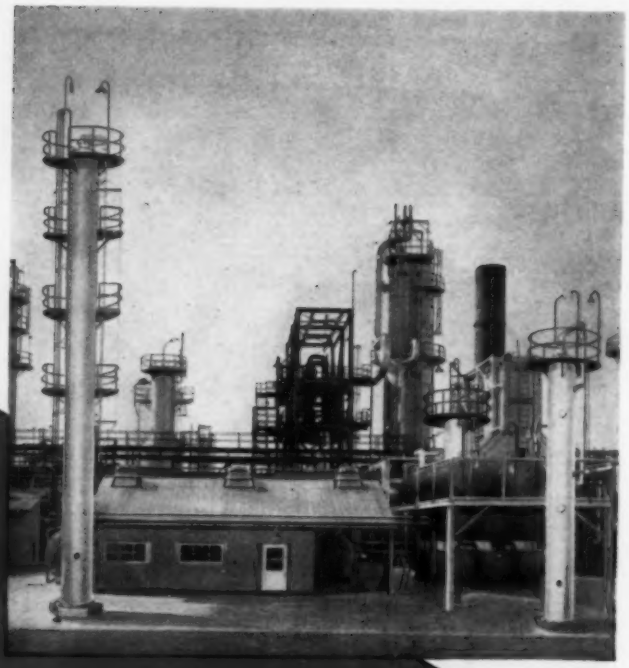

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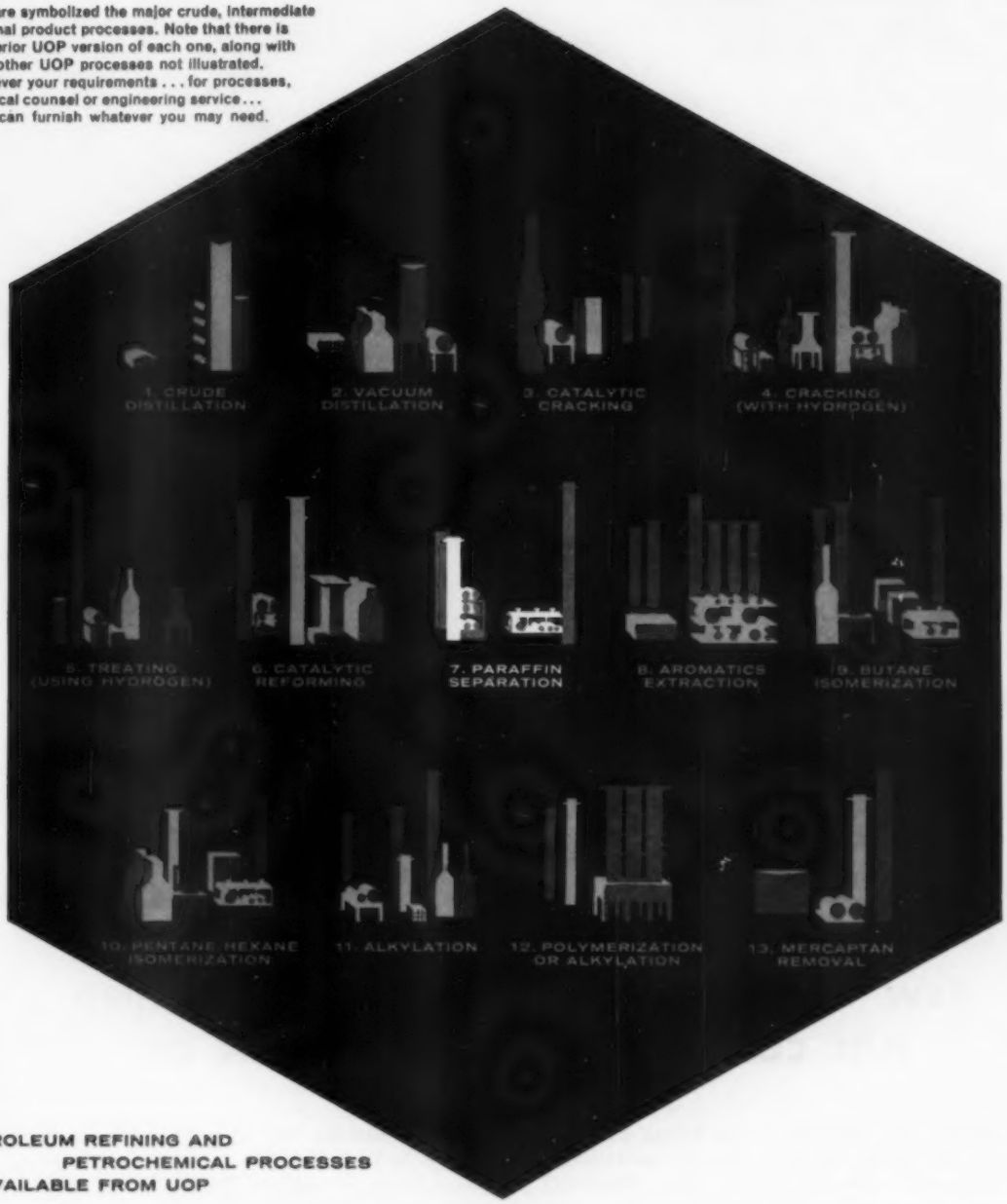
Here are symbolized the major crude, intermediate and final product processes. Note that there is a superior UOP version of each one, along with eight other UOP processes not illustrated. Whatever your requirements . . . for processes, technical counsel or engineering service . . . UOP can furnish whatever you may need.



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Find out how a B&W CO Boiler can Help you Cut Costs. These are practical advantages that can help improve your refinery operations. There are many more that add up to increased efficiency and economy. Get the complete story by writing for Bulletin G-87, The Babcock & Wilcox Company, Barberton, Ohio.

CO-101

B&W

THE BABCOCK & WILCOX COMPANY

BOILER DIVISION

Refractory insulating concrete protects catalyst lines against erosion

Gunite Contractor: J. A. McCollum, Inc., Marlton, N. J. Castables: Kaiser Refractories & Chemicals Div.

In this catalyst line at a large Gulf Coast refinery, steel mesh is being welded into place over a 3-inch lining of refractory insulating concrete made with LUMNITE calcium-aluminate cement. Over the mesh, a 1-inch thickness of high-strength castable will be gunited, providing a 2-component refractory concrete lining that will resist severe erosion and abrasion caused by catalyst fines. Monolithic refractory concrete linings eliminate troublesome mortar joints. They are easily placed, conforming to any contour. Castables are recommended because they are simply mixed with water and placed – concrete reaches service strength in 24 hours. Castables containing LUMNITE cement are available from leading manufacturers of refractories for a variety of applications in refinery equipment. For information, write Universal Atlas Cement, 100 Park Avenue, New York 17, N. Y.

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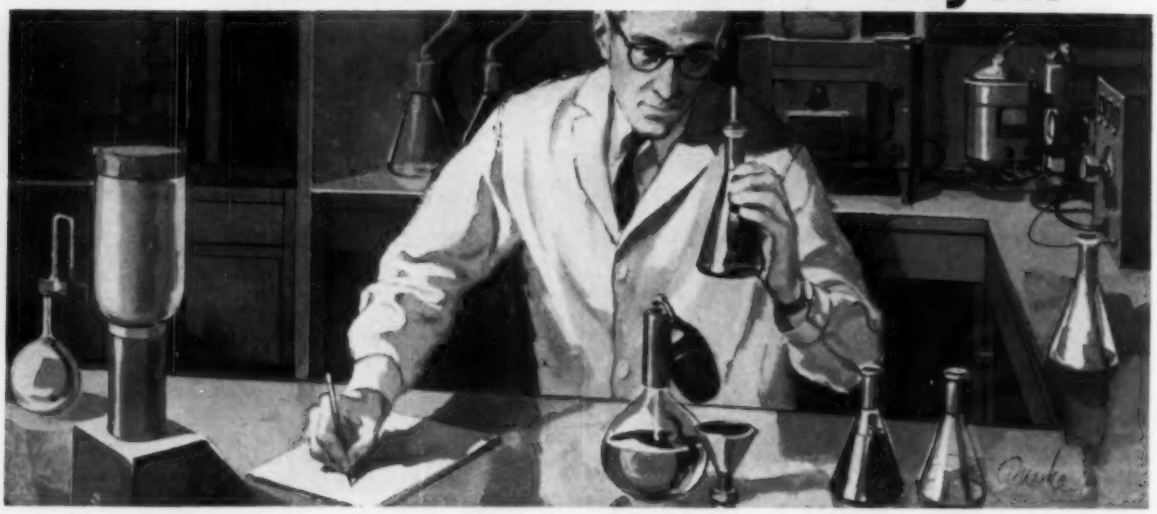

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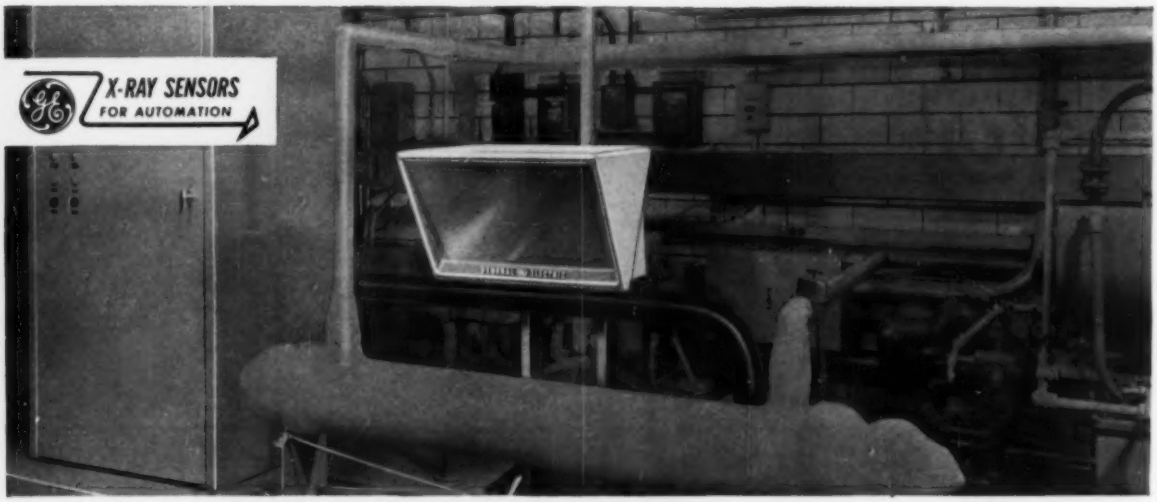

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Progress Is Our Most Important Product

GENERAL ELECTRIC

Lurgi Wet-Contact H_2SO_4 Process

Licensed by: Blaw-Knox Company

DESCRIPTION: The Lurgi wet-contact process produces sulfuric acid from by-product hydrogen sulfide. Essentially, it is a modification of the normal contact process; the principal difference is that the SO_2 is catalytically converted to SO_3 without prior drying of the SO_2. The process is successfully employed in many plants ranging in capacity from 10 to 60 tons per day of 60Bé acid. A wide range of H_2S concentrations can be tolerated in the raw gas stream.

When the H_2S concentration is below 9%, the gas must either be preheated, or burned with oxygen-enriched air, or with fuel gas. A combination of the above may also be used. As the water formed during combustion will dilute the acid, the quantity of fuel gas that can be added will be limited by the acid concentration required. To prevent contamination of the catalyst mass with dust, the air is filtered before entering the system.

After leaving the burner, the SO_2-bearing combustion gases are cooled to about 850F by passage through a waste heat boiler. The cooled gases, along with sufficient additional air to complete the oxidation of SO_2 to SO_3, then enter the catalytic converter which contains several layers of vanadium catalyst. From the converter, the gases pass into the condensation tower where the SO_3 is absorbed by a sulfuric acid spray. The acid mist that leaves the tower is separated from the exhaust gases in the filter and recovered.

PRODUCT AND YIELD:

60Bé (78% by weight) sulfuric acid is normally produced. Sulfur recovery is better than 98%.

CATALYST:

Catalyst life is about five years.

SERVICE FACTOR:

A service factor of better than 95% can be expected.

UTILITIES:

	Per Ton of Acid
Power	40 kw
Cooling Water (10F Rise)	8000 Gal
Steam Produced at 300 psig	1600 to 2000 lbs

OPERATING PERSONNEL:

One part-time operator.

INVESTMENT:

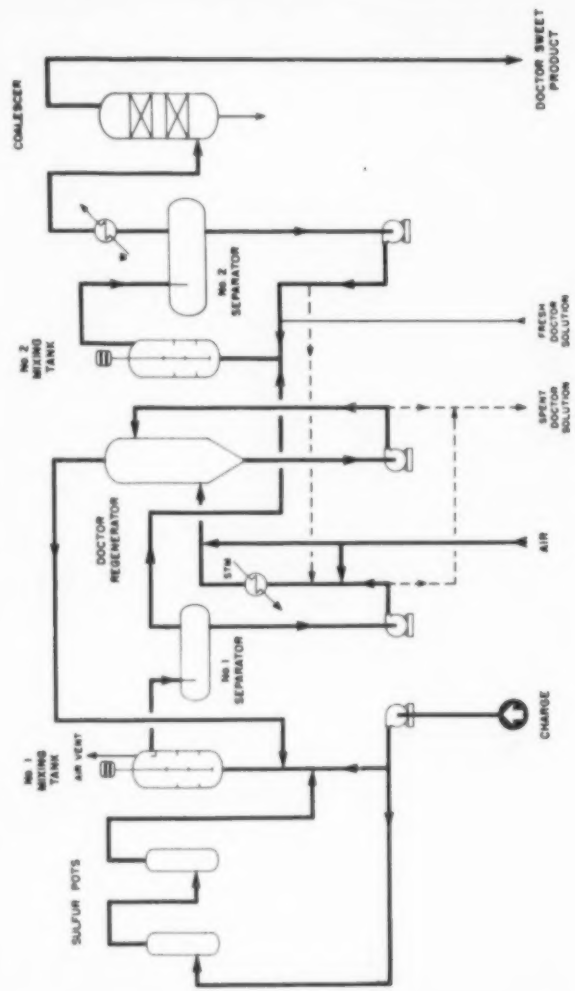
Investment costs depend on the nature of the feed stream and size of the plant, and may be obtained from the licensor.

MAINTENANCE:

Maintenance costs are approximately 1.5% of investment annually.

Doctor Sweetening

Licensed by: The Lummus Company



Doctor Sweetening

Licensed by: The Lummus Company

DESCRIPTION: Doctor Sweetening, one of the oldest processes for sweetening gasoline, solvents, and kerosene, converts mercaptans to disulfides using sodium plumbite and sulfur:

$$2R\,SH + Na_2PbO_2 \rightarrow PbR_2S_2 + 2NaOH$$

$$PbR_2S_2 + S \rightarrow PbS + RSSR$$

The PbS is converted back to Na_2PbO_2 by air blowing in caustic soda:

$$PbS + 2O_2 + 4NaOH \rightarrow$$

$$Na_2PbO_2 + 2H_2O + Na_2SO_4$$

In this process, sulfur and caustic soda are consumed. In addition, some PbO is mechanically lost and some must be added to replace solution discarded because of the accumulation of sodium sulfate and sodium salts of cresols and aliphatic acids.

In this unit, a slipstream from the charge stream passes through sulfur pots and rejoins the main charge stream along with regenerated doctor solution and regeneration air at the bottom of the No. 1 doctor mixer. The sour charge, sulfur solution and regenerated doctor solution are intimately mixed in the No. 1 doctor mixer. Air is vented from the top of this mixer and the treated charge plus doctor solution flow out through a side nozzle to the No. 1 doctor separator.

The hydrocarbon stream leaving this separator is combined with second stage doctor solution and mixed in the No. 2 doctor mixer and then enters the No. 2 doctor separator where most of the doctor solution and lead sulfide formed in the sweetening reaction settle out.

The sweetened stock leaving the No. 2 separator is cooled in the product cooler and passes through the coalescer where residual doctor solution and lead sulfide are removed.

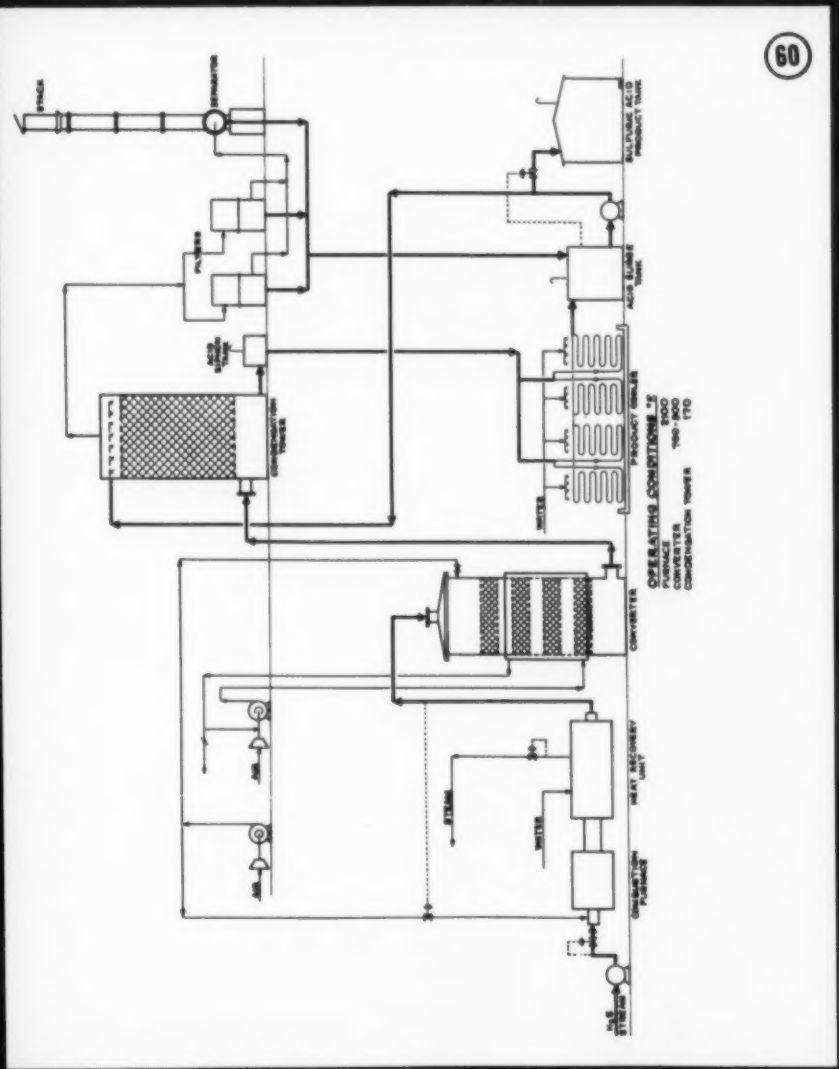
Doctor solution from the No. 1 separator is normally circulated through the doctor heater and regenerator, combined with the regeneration air and delivered back to the No. 1 mixer.

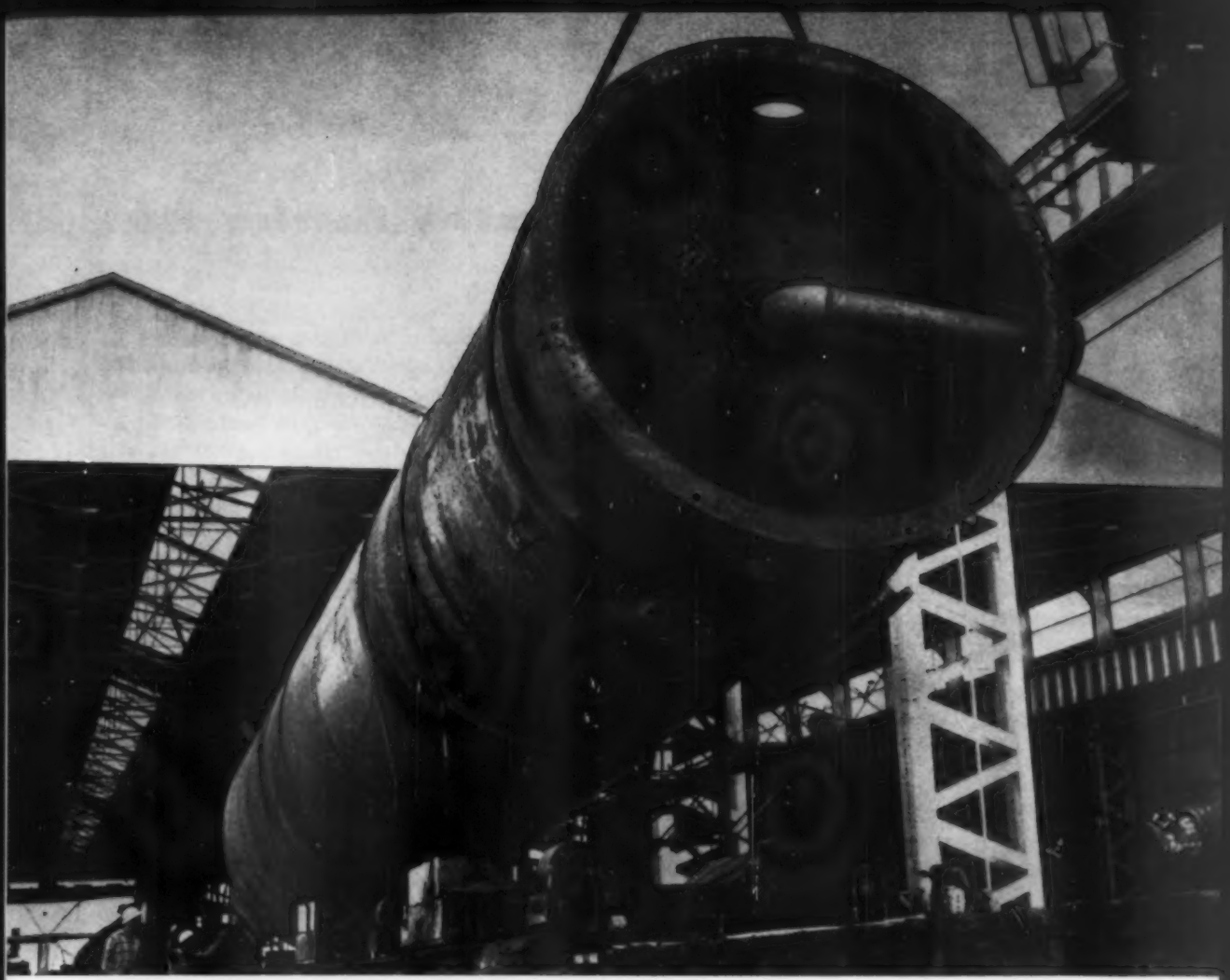
Doctor solution from the No. 2 doctor separator is normally returned directly to the No. 2 mixer. Periodically, this solution is pumped forward to the No. 1 mixer and replaced with fresh doctor solution from storage. When this is done, an equal volume of spent solution from the No. 1 separator is discarded.

Doctor solution is continuously circulated from the bottom of the regenerator to a nozzle located in the side of the regenerator by means of the doctor pump. This circulation prevents lead sulfide from settling out in the regenerator.

Lurgi Wet-Contact H_2SO_4 Process

Licensed by: Blaw-Knox Company





Designed by the Fluor Corporation, Ltd., for the Union Texas Natural Gas Corp.

It took a stork's big brother to deliver this 225-ton baby

High-capacity cranes were needed to handle this giant absorber unit (225 tons, 56′ long, 4″ shell), that required special attention and equipment all along the way. First, it was made of ASTM A212 Grade B Firebox Quality Plate, charpy impact-tested to 15 ft. lbs. @ —50°F. Then it was flame cut and roll formed. Its main stem was 100% radiographed, and its nozzle penetration was magnetic-particle inspected. The entire vessel was then stress relieved at 1150°F. for four hours. And finally, it was placed on special flat cars for delivery. ☐ This kind of job demands the complete, modern, high-capacity facilities that permit our Orange, Texas plate shop to handle all kinds of custom plate work. High-capacity cranes, mammoth car bottom furnaces, giant presses and bending rolls, the latest in welding equipment, and complete inspection facilities. This plus know-how and strategic location permit us to produce all kinds of plate work efficiently and economically. And anything we make, we can erect.

Write for our booklet on plate fabricating facilities and services.

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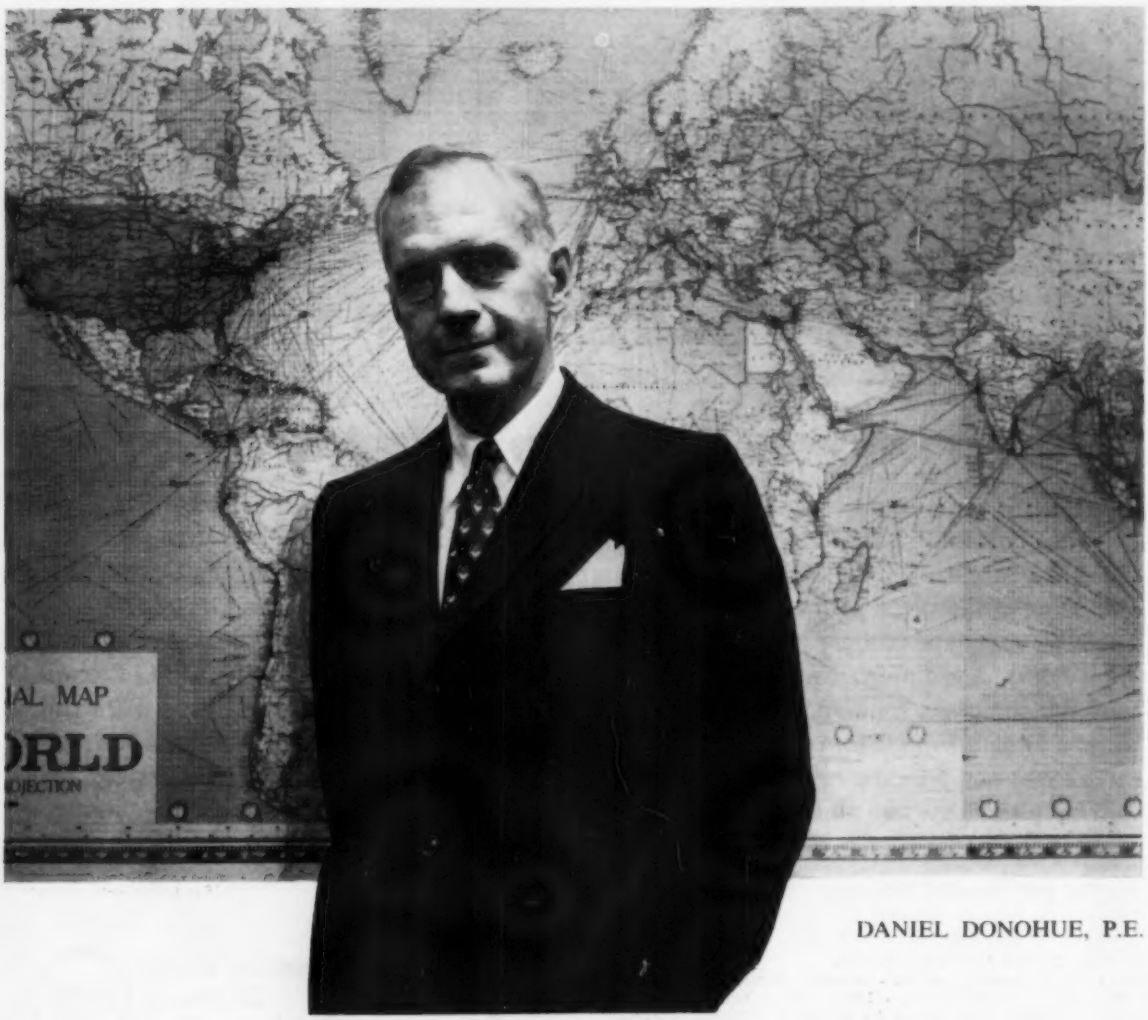
USS

heat transfer in the HPI

HEAT EXCHANGERS represent a substantial item in the cost of Hydrocarbon Process Industry plants. Taking the major pieces of equipment in distillation units to be towers, exchangers, tanks, and pumps, Bach[1] estimates that the total cost of exchangers represents one third of the total. In fact, of all the equipment installed in HPI, heat exchangers represent the third largest segment. **For 1961 the world-wide capital expenditures for heat exchangers will reach $205 million.** At an average cost of $6 per sq ft, this represents an annual consumption of 34,000,000 sq ft of heat transfer surface . . . **enough ¾-in. tubing to reach around the world 1¼ times.** This certainly points up the importance of the project-process design engineer team which has responsibility for the design and procurement of this vast amount of process equipment vital to every plant in the Hydrocarbon Process Industry.

Petro/Chem Engineer emphasizes this important subject in this issue. Some of the country's top experts offer



DANIEL DONOHUE, P.E.

you design engineers technical discussions that will make valuable additions to your engineering files. Let's discuss for a minute some of the recent activities, developments, and trends in this field of heat transfer.

Experimental studies . . . The most important research investigation undertaken within the past decade has been carried out at the **University of Delaware.** Its objective has been to investigate shell-side flow in segmentally-baffled heat exchangers in order to evaluate the factors governing heat transfer and pressure drop. The initial step was a study of simple crossflow across tube banks of various tube sizes and configurations. Next a cylindrical shell-and-tube exchanger, in which all of those leakage areas which are necessarily always found in industrial units and result from required mechanical clearances had been sealed off, was tested. Then the leakage areas were opened up one by one and the results compared with the sealed unit. The results proved so complex that the study of one variable brought up questions about the effect of others. Supplementary studies were undertaken with orifice flow. The procedures followed and some of the results are described by **Dr. Kenneth J. Bell** who was engaged in some of the latter experimental work at the University of Delaware and is now on the faculty at Case Institute of Technology.

Air cooling . . . That air can be used for cooling hot fluids and condensing vapors has long been known and used, to a limited extent, when water was either not available or of such poor quality as to be completely unsuitable. However, with the last three or four years the thinking about the use of air cooling in Hydrocarbon Process Industry plants has been completely altered and in several instances atmospheric air has been employed as coolant instead of water. The conditions responsible for this change have been the increasing shortage of available cooling water and increased costs for installation and maintenance of water-cooling systems. When making the choice between air or water as coolant it is necessary to make a detailed comparison and analysis of each system to discover the relative advantages and disadvantages of each. For the air-cooling system the equipment cost is represented by the cost of the air coolers only, whereas for the water-cooled system the equipment required consists of the water-cooled exchangers plus any additional equipment which may be required to provide cooling water at the plant site. Often in the past cooling water has been drawn from a nearby available source such as river or lake, circulated through the coolers and discharged. With fair quality water and short lengths of piping this is the simplest and least expensive cooling system. However, when the source of water is remote from the site the costs of pipe lines and pumping can be substantial and must be included in the economic balance. At other sites where water is too expensive the cooling water is recirculated and the heat picked up is dissipated in a cooling tower which adds considerable to the cost of the installation.

Another consideration is the scale-forming tendency of the cooling water. When hard water is used as coolant scale-forming compounds such as calcium carbonate or calcium sulphate will deposit inside the tubes and build up over a period of time necessitating shut-downs for cleaning at periodic intervals. Recirculation builds up the concentration of solids to several times that in the original supply in which case chemical treatment is usually applied to counteract the scale-forming tendencies of these dissolved solids.

With air cooling the problem of coolant fouling is eliminated. The most important factor influencing an air cooler is temperature: the dry-bulb and the wet-bulb temperatures of the ambient air and the outlet temperature of the process stream.

When all of these factors are evaluated economically the choice of coolant can be decided. In many cases where air cooling has been indicated as preferable it proves most advantageous when the process streams are cooled to approximately 140 F by air, and final cooling to 100 F is carried out in an auxiliary water-cooled exchanger known as a trim cooler.

Standard heat exchangers . . . During the past 35 years companies engaged in the design and manufacture of heat-transfer equipment for the Hydrocarbon Process Industry have developed certain techniques which have standardized manufacturing practice to a considerable extent. The extent of this standardization is embodied in the publication *"Standards of Tubular Exchanger Manufacturers Association."*[2] However, the actual size and disposition of flow areas is left to the experience and

judgment of the specially-trained designer of heat exchangers; and the selection of suitable materials of construction is arrived at by agreement between user and designer. Experience has been that custom design has been the most economical for all units except the smallest.

In the last five years a growing customer, the chemical industry, has been demanding something new. They want a series of completely standardized or pre-engineered units from which they can select the size nearest their particular requirements. To a large extent pumps are produced on this basis, and the feeling is that if it can be done with pumps, valves and instruments why not with exchangers? This is the technique of mass production by which cars and electric household appliances are produced. *Who would spend the time and money to have an electric toaster specially designed and built with all the models available on the shelf?*

It may be noted that heat-exchanger manufacturers do not object to standard exchangers per se. There are many heat exchangers which are completely standardized and can be purchased off the shelf just like pumps and valves. One example is oil coolers which lend themselves to standardization for two reasons: small capacity and similarity of operating conditions wherein the only variable is capacity.

The standard units now on the market have been impressed into various services. However, these units may be too small or inadequate for larger or more specialized performance. For such applications, which are typical of most refinery duties, there are two possible solutions. First, extend the line of standard units to larger sizes; or second, design each unit individually for the particular performance. The first procedure, requiring the use of a standard unit, would be inefficient as a consequence of the wide variation in fluid-flow rates for various operating conditions. The second procedure yields a unit which is properly and efficiently designed and costs less. If all purchasers and vendors agreed to buy and manufacture only standardized units the market would be on a firm and equitable basis even with the attendant inherent inefficiency of such units. Setting up these engineering standards would be a costly undertaking for the many manufacturers in the business. If, during periods of intensive competition, users found they could effect savings by abandoning standard units in favor of custom design the entire plan would be scuttled.

The entire subject hinges about the ever-present basic point, **economy.** If standard heat exchangers can be produced to offer a properly-designed unit at a lower cost the manufacturers will standardize their lines completely; if not, they will continue to custom design each unit.

Procurement of heat exchangers . . . To the best of our knowledge nothing has ever been published about the procurement of heat exchangers although the subject is one of the greatest importance. How much better that the buyer obtain a properly-designed unit at a reasonable cost rather than the cheapest unit which fails to do its job. To handle this assignment we went to the man best qualified for it, **Charles H. Gilmour** of Union Carbide Chemicals Company. It is a pleasure to note that Mr. Gilmour has scored a succession of hits on the bull's-eye with his pithy remarks reflecting the concentrated experience of almost thirty years in this field. Mr. Gilmour is the author of numerous papers which have contributed much to a better understanding of heat-transfer equipment among engineers.

1. Bach, N. G., *Chemical Engineering*, 65, 155-9, Sept. 22, 1958.
2. Tubular Exchanger Manufacturers Association, Inc., "Standards of Tubular Exchanger Manufacturers Association," Fourth Edition (1959).

ABOUT OUR SPECIAL ISSUE EDITOR

As an authority on heat transfer, *Petro/Chem Engineer's* special editor for this issue is internationally recognized.

Daniel Donohue, head of the heat exchanger section of Chemical Construction Corporation, New York, has been professionally engaged in the design of all types of heat exchangers for 23 years.

His method of designing heat exchangers, detailed in a number of published articles, has become an accepted procedure for this equipment.

He is also active in a teaching capacity, serving as an adjunct professor in the Department of Chemical Engineering at Brooklyn Polytechnic Institute Evening Graduate School where he has been on the staff since 1951.

He is registered as a professional engineer in both New York and New Jersey.

A native New Yorker, he holds a degree in chemical engineering from Brooklyn Poly and an AM in chemistry from Columbia University.

He was with Griscom-Russell Company, New York, from 1937 to 1942, and with the Lummus Company, New York, from 1942 to 1952, when he went with Chemico.

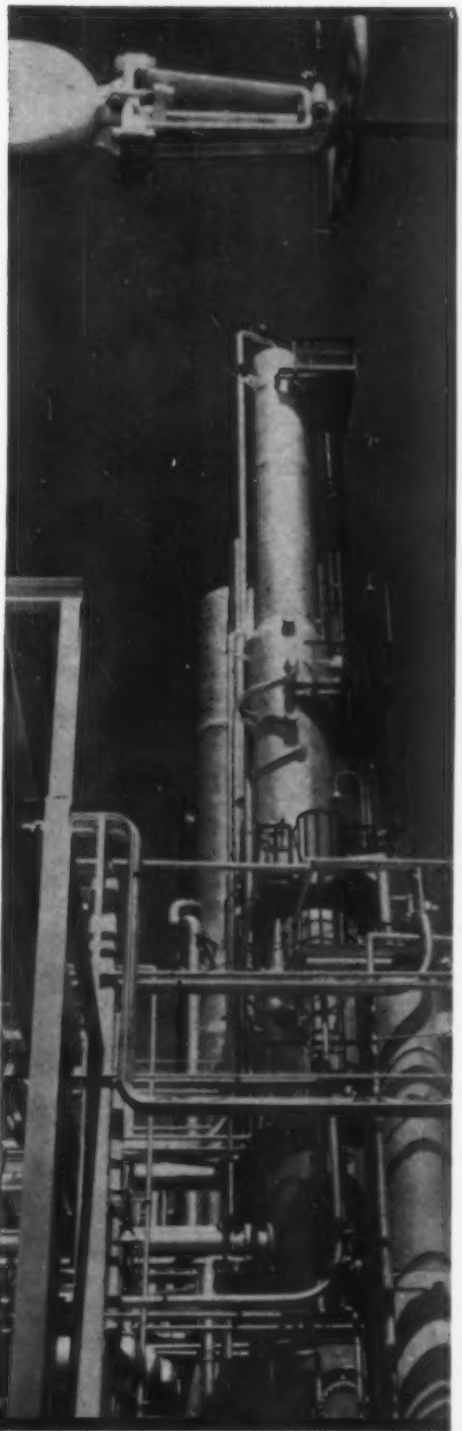
His particular fields of interest are the mechanical and chemical aspects of heat transfer, distillation, fluid flow, and mechanical fabrication techniques. He has designed heat transfer equipment for aviation gasoline, synthetic rubber, and other petrochemical and chemical plants; feedwater heaters, and surface condensers.

He has written articles for technical magazines on heat exchanger design, heat transfer coefficients for condensing hydrocarbon vapors, and heat transfer and pressure drop in heat exchangers.

Petro/Chem Engineer wishes to extend very sincere thanks to Daniel Donohue for his able assistance in planning contents, securing authors, and coordinating their efforts to bring you this group of outstanding articles on the vital subject of heat transfer in the Hydrocarbon Processing Industry.

Oakite ECP
engineered cleaning program

clears scale-choked catalytic reformer furnace in 2 days



Sulphur-platinum-carbon scale cut heat-transfer ability so severely that a catalytic reformer furnace was operating below capacity. Gasoline production dropped sharply. Moreover, the all-welded unit couldn't be dismantled for manual cleaning.

That prompted a call for the Oakite engineer. In developing an ECP, he recommended circulating a solution of specific Oakite Compounds through the choked tubes. The two acidic materials used as recommended were safe for the low chrome steel furnace tubes. This solution was circulated for four hours through each of the four sections of the furnace: convection, preheat, #1 reheater and #2 reheater. It took just two days to descale the tubes completely, putting the reformer unit back to producing over 3000 barrels a day.

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Exchanger Design . . .

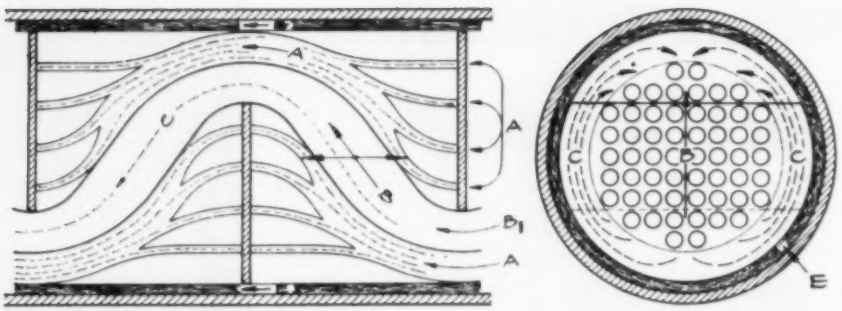


FIG. 1. Schematic diagram of streams on shell side of baffled heat exchangers.

DR. KENNETH J. BELL
Assistant Professor of
Chemical Engineering
Case Institute of Technology
Cleveland, Ohio

THE COOPERATIVE RESEARCH PROGRAM on baffled shell and tube heat exchangers at the University of Delaware carried out experimental and analytical studies on the shell-side phenomena in heat exchangers over a course of a dozen years. The chief result of this program was the accumulation of a large amount of carefully obtained experimental data whose final interpretation is perhaps yet years away due to the sheer bulk of information obtained and the complexity of the shell-side problem. From time to time various workers on the project have suggested how these data could be applied to improve the design and design methods of exchangers. Surveying these various design contributions, the author has selected a few pieces and assembled them in a coherent form which appears reasonable for the design of exchangers at this time. This is the first time that the Delaware project has suggested a design procedure encompassing all of the usually encountered shell-side features of an exchanger.

This procedure is derived from generally accepted models of the various fluid flow and heat transfer mechanisms on the shell-side supported by data obtained to specifically illuminate each mechanism individually. At almost every step, it is possible to suggest a more rigorous (hence presumably more accurate) treatment than that employed here; the author's choices of where to draw the line are certainly challengeable and the engineer is encouraged to choose and modify as the problem demands.

Dr. Kenneth J. Bell

based on the Delaware research program

FLOW PATTERNS and temperature profiles on the shell side of baffled shell and tube heat exchangers have long been recognized as extremely complex, and the thermal-hydraulic design of such exchangers is more a matter of experience and intuition than science.

To permit the mechanical assembly and disassembly of such a heat exchanger requires that there be small clearances between the tubes and the baffles and between the baffles and the shell. For some exchanger designs there is also a substantial clearance between the outermost tubes and the inside of the shell. Since there are pressure drops across these various alternate flow paths, there is a substantial flow through these paths in addition to the prescribed ideal flow through the tube bundle and through the baffle turnaround (window) from one crossflow section to the next. The presence of these alternate streams adversely influences the local velocities in the exchanger and therefore decreases the local heat transfer coefficients and the local pressure gradient. Additionally, these alternate streams adversely distort the ideal temperature pattern in the exchanger.

Fig. 1[1] shows the complex flow problem on the shell side of the exchanger. Stream B is the desired crossflow stream, Stream A is the leakage stream through the clearance between the tubes and the baffle, Stream E is the leakage stream through the clearance between the baffles and the shell, and Stream C is the bypass flow stream along the outside of the tube bundle between the outermost tubes and the shell.

A rigorous approach to the design of shell and tube exchangers would require that the relative resistances of all of these streams be known and that the interaction and exchange of fluid be known. Such information is not presently available, although a start has been made toward obtaining it, and a design procedure based on such a rigorous analysis would probably be too complex and time-consuming to be of interest in the vast majority of exchanger design calculations.

There are two different approaches to a practical handling of the exchanger design problem that are well established in the literature and in practice. The first is by means of dimensional analysis. The pressure drop and the heat transfer rate may be empirically related to a small number of dimensionless groups embodying the characteristics of the fluid in question and the geometrical features of the shell side. If all of the important geometrical features of the shell side (i.e., tube diameter, arrangement, and pitch; baffle spacing and cutdown; shell diameter; tube-to-baffle, shell-to-baffle, and bundle-to-shell clearances) were to be considered, a complete dimensional analysis would require a vast amount of data which is simply not available and a difficult computation problem in reducing these data to determine the empirical constants. Dimensional analysis in any case lends no great confidence to designs in which it is necessary to extrapolate the original analysis. The second approach attempts to establish the nature of the physical mechanisms existing in the exchanger, to evaluate the effect of these mechanisms on pressure drop and heat transfer, and to sum the individual mechanisms into a total exchanger effect.

The second approach has two important advantages over the dimensional analysis approach. It requires less data, and there is greater confidence in the extrapolation to new and untested designs. On the other hand, the mechanism approach presupposes a clear picture of the controlling processes and how they may be combined into a final analysis. Often the best method is to combine both methods, using the mechanism approach to suggest the proper form of the dimensionless correlations. *The American Society of Mechanical Engineers — University of Delaware Cooperative Research Program on Heat Exchangers* was established to explore at length the mechanism approach to the design of heat exchangers and to use the best of both methods in the development of a design procedure.

The philosophy for this study was to regard the baffled shell and heat tube exchanger as a series of ideal tube banks connected by flow turnaround (window) regions with short-circuiting of the flow by the three alternate leakage flow paths described above. Given this approach to the problem, it follows that one studies first pressure drop and heat transfer in ideal tube banks, then the phenomena occurring during flow through the baffle window or turnaround, and finally the individual leakage phenomena. The study at Delaware covered a period of a dozen years of active experimental work and a continuing period of analysis of the data obtained. The "final interpretation" of the Delaware data, if indeed there is to be any such thing, has not yet been made. But it is now possible to present a picture of the processes occurring on the shell side and a preliminary design method based upon that picture.

Flow across banks of tubes

First task of the Delaware project was to examine the state of knowledge concerning flow normal to rectangular banks of tubes. In the turbulent flow regime many good studies have been published in the literature and correlations proposed for these data. The data and correlation of Pierson, Huge and Grimison[2,3,4] were particularly complete for Reynolds numbers between 4000 and 40,000, and Grimison's correlation had much to recommend it.

In the laminar and transition flow regimes,* however,

*The following arbitrary division of flow regimes is used throughout this paper:

Laminar	$D_t G_m/\mu < 100$
Transition	$100 < D_t G_m/\mu < 4000$
Turbulent	$4000 < D_t G_m/\mu$

Model No.	Arrangement	Rows	OD, in.	Pitch Ratio
1	Triangular	10	⅜	1.25
2	Square, in line	10	⅜	1.25
3	Square, staggered	14	⅜	1.25
4	Triangular	10	⅜	1.50
5	Square, in line	10	⅜	1.50
6	Square, in line	10	¾	1.25
7	Square, staggered	14	¾	1.25

Models 6 and 7 gave results identical to those of Models 2 and 3, respectively.

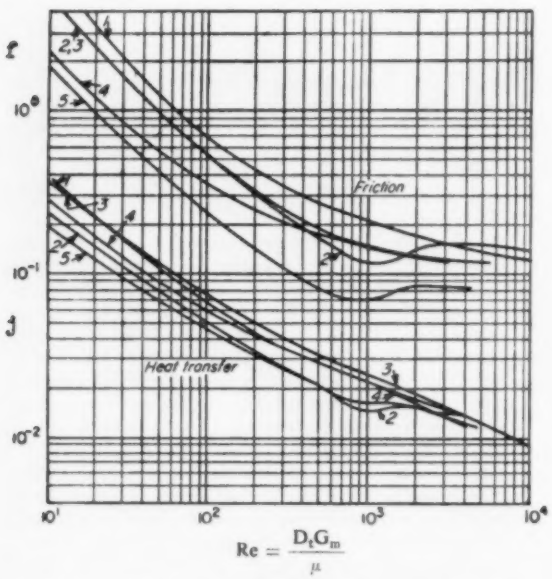


FIG. 2. f and j factors for seven ideal tube banks in laminar, transition, and early turbulent regimes.

there were very few published data, and those were not very consistent. Therefore, using seven tube banks, the Delaware project studied friction factors and j-factors in the Reynolds number region from 1 to 10,000. Later studies extended the curves to even lower Reynolds numbers and showed that they could be safely extrapolated in that direction.

The Delaware data[12] are summarized in Fig. 2, which plots friction factor and j-factor versus the Reynolds number defined on the basis of the tube diameter and the velocity through minimum crossflow area in the tube bank. Several features of the curves should be noticed. At low Reynolds numbers the slope of the friction factor curve is −1 and the slope of the j-factor curve is −⅔ as required by theory. Hence one may confidently extrapolate these lines to arbitrarily low Reynolds numbers as required. In the transition flow regime the staggered tube banks show a smooth, always-decreasing curve with increasing Reynolds numbers, whereas the inline tube banks show a marked dip in both friction factor and heat transfer. Visual experiments here indicated that, for the staggered tube banks, turbulence begins at the downstream tube row and slowly builds up through the bank with increasing Reynolds numbers until the entire tube bank is in turbulent flow. The inline tube banks, however, behave more like rough-walled conduits, and the transition from laminar to turbulent flow is much more definite and corresponds to the region of positive slope of f and j.

It is possible to predict curves of f and j as a function of Reynolds numbers for tube banks of geometries different from those tested. First, the rules of geometric and hydrodynamic similarity hold; i.e., the curves of f and j versus Re for all equilateral triangular tube banks of 10 rows with a 1.25 pitch ratio are identical.* In the turbulent regime Grimison's correlation involves the use of geometrical configuration factors covering the entire range of interest of longitudinal and transverse pitch ratios. In the laminar regime the friction factor curve can be predicted by a new method,[5] though no corresponding method has been developed for predicting the j-factor curve. Bergelin, Colburn, and Hull[6] suggest for the laminar regime

$$j = 1.4 \left(\frac{D_v G_m}{\mu}\right)^{-2/3} \pm 20\% \text{ for seven tube banks tested, } \frac{D_v G_m}{\mu} < 100 \qquad (1)$$

In the transition region one may fair in the curve between the predicted laminar and fully turbulent curves, making use of the difference in behavior observed between inline and staggered arrangements.

The correction for non-isothermal effects on f and j has been studied, and for most cases it is found that the factor $(\mu/\mu_s)^{0.14}$ is quite satisfactory over the entire Reynolds number range. Hull[6] does recommend the use of $\left(\frac{\mu}{\mu_s}\right)^m$ where $m = 1.57\ Re^{-0.25}$ for non-isothermal corrections on f in the laminar regime, but for most purposes the additional refinement seems to be unnecessary.

There are data from several sources (e.g.[6,7]) that indicate that f (in the transition and turbulent regimes) and j (all flow regimes) are dependent upon the number of tube rows in the direction of flow. In the laminar regime, $j \sim N_c^{-n}$ where by limited data, $n = 0.18$; this is attributed to the building of an adverse temperature gradient which is not completely dissipated by expansion-contraction induced mixing. This effect is important in the design of baffled units. In the turbulent regime, as shown in Table 2, f and j vary markedly with N_c for the first few rows and become essentially identical to asymptotic values for $N_c \cong 6$; the mean f and j for banks of 7 or more rows are within 10% of the asymptotic value. The probable explanation of this effect is that it requires a few rows for fully developed turbulence to be established. Since the baffle turnarounds are very effective in inducing and maintaining turbulence, baffled exchangers operate at essentially the asymptotic values of f and j. In general, it is not necessary to consider the effect of number of tube rows on f. However, the effect on j is very important in the laminar regime and worth considering in the turbulent regime.

The results in Fig. 2 apply only to tube banks in which the tubes extend to or are imbedded into the side walls. If there is any spacing between the outer tubes and the wall, a disproportionate fraction of the flow will proceed through this bypass area and significantly reduce the effective heat transfer rate and the pressure drop. The bypass effect is especially serious in the laminar regime. Table 1 gives some of the results found.[8] A simple empirical rela-

*Strictly speaking, the tube length to diameter ratio should also be constant; this effect is very small and may be neglected if $\frac{L_t}{P - D_t}$ is greater than 5, which is almost always the case in practice. Results for Models 6 and 7 verify this.

TABLE 1. Effect of Bypassing on Heat Transfer and Pressure Drop

Laminar Regime.

Percentage of isothermal pressure drop for ideal bundle, Model 4, $100\left(\frac{\Delta p_{BP}}{\Delta p_B}\right)$

Geometry	
Ideal bundle	100
21% bypass area	42
30% bypass area	22
21% bypass area, one seal strip	68

Percentage of shell-side coefficient for ideal bundle, Model 4, $100\left(\frac{h_{BP}}{h_B}\right)$

Geometry	Heating	Cooling
Ideal bundle	100	100
21% bypass area	79	76
30% bypass area	65	60
21% bypass area, one seal strip	94	89

Turbulent Regime.

Percentage of isothermal pressure drop for ideal bundle $100\left(\frac{\Delta p_{BP}}{\Delta p_B}\right)$

Geometry	Model 1	Model 4
Ideal bundle	100	100
21% bypass area	55	43
30% bypass area	38	31
21% bypass area, one seal strip	71	67
30% bypass area, one seal strip	....	63
21% bypass area, two seal strips	81	

Percentage of shell-side coefficient for ideal bundle, $100\left(\frac{h_{BP}}{h_B}\right)$

Geometry	Model 1 Heating	Model 1 Cooling	Model 4 Heating	Model 4 Cooling
Ideal bundle	100	100	100	100
21% bypass area	78	78	80	77
30% bypass area	67	67	73	69
21% bypass area, one seal strip	90	87	94	89
30% bypass area, one seal strip	....	....	88	85
21% bypass area, two seal strips	87	93		

TABLE 2. Variation of $\frac{h_m}{h_a}$ with N_c in Turbulent Flow for Staggered Tube Arrays.

N_c	1	2	3	4	5	6	7	8
$\frac{h}{h_a}$	0.63	0.76	0.93	0.98	0.99	1.0	1.0	1.0
$\frac{h_m}{h_a} = \chi_t$	0.63	0.70	0.77	0.83	0.86	0.88	0.90	0.91
N_c	9	10	12	15	18	25	35	72
$\frac{h}{h_a}$	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
$\frac{h_m}{h_a} = \chi_t$	0.92	0.93	0.94	0.95	0.96	0.97	0.98	0.99

TABLE 3. Dimensions of Cylindrical Test Exchangers.

	Model 9	Model 10
Inside shell diameter, in.	5.25	8.378
Number of tubes	80	470
Length between tube sheets, in.	16.125	16.126
Baffle thickness, in.	0.0625	0.0625
Tube arrangement	Staggered Square	Triangular
Tube pitch ratio	1.25	1.33
Tubes	⅜", 18 BWG	¼", 18 BWG
Total heat transfer area, A, Sq. ft., approx.	9.90	39.40

tionship that fairly closely represents the results of Table 1 and condenses to the proper limiting cases is

$$\left.\begin{aligned}\xi_{\Delta p} &= \frac{\Delta p_{BP}}{\Delta p_B}\\ \xi_h &= \frac{h_{BP}}{h_B}\end{aligned}\right\} = e^{-\alpha F_{BP}}\left[1 - \sqrt[3]{\frac{2N_s}{N_c}}\right]$$

$$\text{for } N_s \leq \frac{N_c}{2}$$

where F_{BP} is the fraction of the total minimum crossflow area that is in the bypass stream and α is a constant taken from the following table:

	laminar	*turbulent*
$\frac{\Delta p_{BP}}{\Delta p_B}$	4.5	3.8
$\frac{h_{BP}}{h_B}$	1.25	1.25

Baffled cylindrical heat exchangers with no baffle leakage

Following the ideal tube bank studies the next step in the Delaware project was to study the problem of baffled cylindrical exchangers in which the leakage streams were eliminated by experimental technique and design. Shell-to-baffle and baffle-to-tube leakage was eliminated in the test exchanger by coating the baffles with a thin layer of neoprene and then overcutting the neoprene on the shell side and undercutting on the tube holes. The resulting neoprene flaps effectively gasketed the clearances. The bypass stream was minimized by the use of tube layouts that matched quite closely the shell curvature without distorting the unit cell geometry of the tube bank. Baffle spacers were placed in the more open bypass areas. Later data suggests that the fractional bypass area, F_{BP}, of about 0.05, does introduce significant errors which must be considered in the interpretation of the data. Important geometric features of the cylindrical test exchangers are given in Table 3.

Mechanism proposed by the Delaware workers regarded the baffled cylindrical exchanger as a series of ideal tube banks, whose behavior is presumably well understood, connected by turnaround areas (windows) whose influence can be studied as a function of baffle spacing and cutdown. To verify this assumption and to obtain the pressure drop distribution, dummy pressure tap tubes were inserted in the test exchangers so that the pressure drops across a single crossflow section and across a single window section could be measured. Later in the work internal temperature profiles were obtained by a similar technique.

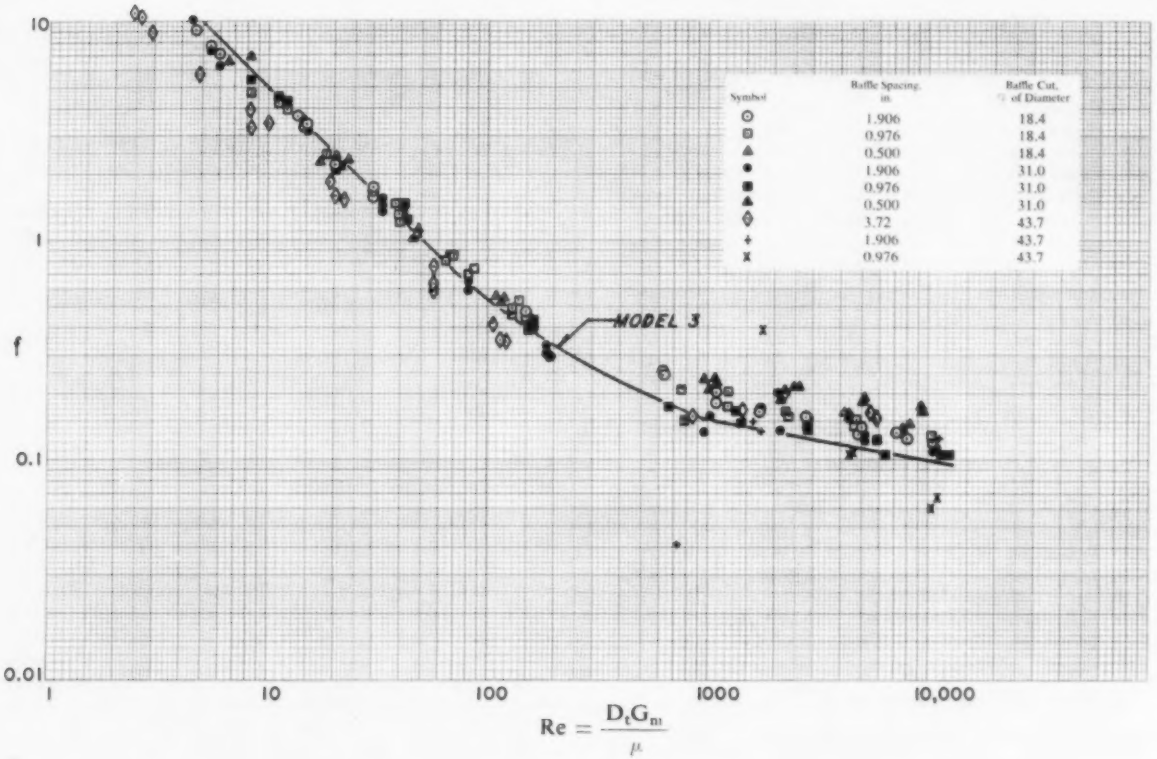
The results of Brown[9] using Model 9 for nine combinations of baffle spacing and cutdown over a Reynolds number range from 600 to 14,000 and of Tompkins[9] in the Reynolds number range from 2 to 200 for the pressure drop across a single crossflow section are shown in Fig. 3. The solid line in Fig. 3 is the curve for the ideal rectangular tube bank having the same tube layout as the cylindrical exchanger. The baffled exchanger results have been examined before plotting for bypass stream effects. Using Equation 2 with $F_{BP} = 0.05$, one finds for the laminar regime

$$\xi_{\Delta p_l} = \frac{\Delta p_{BP}}{\Delta p_{NBP}} = 0.798 \approx 0.80$$

and for the turbulent regime

$$\xi_{\Delta p_t} = \frac{\Delta p_{BP}}{\Delta p_{NBP}} = 0.839 \approx 0.84$$

FIG. 3. Correlation of $f = \frac{2\Delta p_B g_c \rho}{4\xi \Delta_p G_m^2 N_c} \left(\frac{\mu}{\mu_s}\right)^{0.14}$ vs Re for crossflow section, Model 9.



Therefore, for comparison with the ideal tube bank results, the single baffle section pressure drops have been divided by the above ξ's and plotted in Fig. 3. The turbulent flow results vary $^{+70}_{-10}$ % and the laminar results $^{+30}_{-50}$ % about the line for the ideal tube bank.

A later study by Leighton using Model 10, an exchanger with more than twice as many rows of tubes between the baffle cuts as Model 9, gave results within ±10% of the corresponding ideal tube bank results, suggesting that the concept of using ideal tube banks results works better when there is a large number of rows of tubes in the crossflow section. To correct for non-isothermal effects on the friction factor the use of $\left(\frac{\mu}{\mu_s}\right)^{0.14}$ is recommended. There does seem to be some dependence of the exponent on Reynolds number for very low Reynolds numbers, but the effect appears not to be significant for most cases of practical interest.

Pressure drop through a single window section was measured on these same exchangers for a variety of baffle spacings and cutdowns, again both in the laminar and turbulent regimes. If the window pressure drop is plotted versus the window velocity alone, the pressure drops in the windows vary by a factor of 10 to 1 or more. The highest pressure drops are found for combinations of close baffle spacing and large baffle cutdown, indicating that a high crossflow velocity leads to a high pressure drop in the baffle window. When the window pressure drops are plotted versus the geometric mean window velocity $V_g = \sqrt{V_m V_w}$, the results fall within about ±50% of a straight line, suggesting the use of the geometric mean window velocity as the prime correlating variable.

Colburn[10] suggested that the pressure drop in the window could be separated into a contribution due to the reversal of flow from one crossflow section to the next and a contribution due to the flow of the fluid across a characteristic number of tube rows in the window. The pressure loss due to reversal of flow is taken to be $2\left(\frac{\rho V_z^2}{2g_c}\right)$ for both the laminar and turbulent regimes. Colburn considered the laminar and turbulent regimes separately in his evaluation of the frictional losses due to flow across the tubes in the window. As a measure of frictional losses in laminar flow he defined a viscosity-velocity unit, $\frac{V_\mu}{sg_c}$, which is analogous to the velocity head so often used in turbulent flow calculations.

This particular choice of variables is suggested by the fact that the wall shear stress in laminar flow is equal to $\frac{\mu}{g_c}\left(\frac{du}{dy}\right)$ where $\left(\frac{du}{dy}\right)$ is the velocity gradient normal to the solid surface. In irregular geometries such as tube banks, $\left(\frac{du}{dy}\right)$ is of the same order of magnitude as the maximum velocity divided by the minimum spacing from tube to tube, $\frac{V_m}{s}$. For the tube bank geometry used in Model 9 the pressure loss per restriction in the laminar regime is equal to $23\ \frac{\mu}{g_c}\ \frac{V_m}{s}$. Applying this to the case of a baffle window, the velocity used in the viscosity-velocity

unit is the geometric mean velocity V_z, and the number of restrictions N_w is taken to be the average number of restrictions crossed by the flow through the window. N_w is approximately the number of tube rows between the baffle cut and the shell, but due allowance must be taken here for the presence of relatively small number of tubes in the outer rows. Any tube row that has fewer than half the tubes of the central row is not counted.

In principle, the bypass effect must be taken into account by multiplying by $\xi_{\Delta p,1}$ which is 0.798 for the case tested. Colburn also applies the viscosity-velocity unit concept to the case of flow parallel to the tubes, again using for the velocity term the geometrical mean velocity V_z, but now using as the characteristic dimension the volumetric equivalent diameter D_v of the window region. As a measure of the length of parallel flow path, he uses the ratio of the baffle spacing to the volumetric equivalent diameter, L_B/D_v. Available data for longitudinal laminar flow suggest 26 velocity-viscosity units per unit $\frac{L_B}{D_v}$. No allowance for bypassing is made, since it is much less important in longitudinal flow (where most of the flow occurs in the central open regions of the unit cell of the tube array), and since the value of D_v reflects any change in the clearance between bundle and shell. Summing these terms gives

$$\Delta p_{w,1} = 23\,\xi\Delta p_{,1}\left(\frac{\mu V_z}{g_c s}\right) N_w + 26\left(\frac{\mu V_z}{g_c D_v}\right)\left(\frac{L_B}{D_v}\right) + 2\left(\frac{\rho V_z^2}{2g_c}\right). \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

For calculation of the pressure drop due to flow across the tubes in the window in the turbulent regime, Colburn suggested that 0.6 of a velocity head be lost for each restriction crossed by the entire flow in the window. The use of 0.6 corresponds to a friction factor of 0.15, which is larger than that found for tube banks at Reynolds numbers above about 10,000. In view of the other assumptions and approximations in the argument, further refinement is pointless. Then the total window pressure drop in turbulent flow can be estimated by:

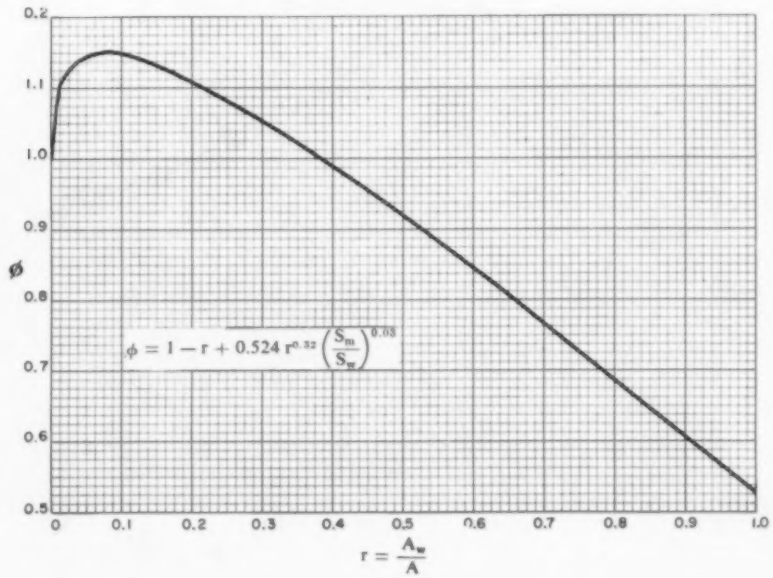
$$\Delta p_{w,t} = (2 + 0.6N_w)\,\frac{\rho V_z^2}{2g_c}. \quad . \quad . \quad . \quad (4)$$

Colburn's method predicts the window pressure drop for the test configurations within ±20% in the laminar regime and from −30 to +20% in the turbulent regime.

Calculation of pressure drop across the entire exchanger by summing individual pressure drops presupposes that all crossflow and window sections behave in essentially the same fashion. Leighton[9] measured all of the individual pressure drops in his exchanger and found that there was no more than ±15% variation in the no-leakage exchanger about the mean value for the window pressure drops and somewhat less variation for the crossflow pressure drops. Brown and Tompkins, who measured pressure drops for only one crossflow section and one window section, found ratios of the measured overall pressure drops to the summation of the measured individual section pressure drops to vary from 0.97 to 1.33. The greatest deviations were for the cases of wide baffle spacing and large baffle cutdown which lead to a low resistance heat exchanger, suggesting that at least some of the remaining effects were due to nozzle losses which could not be accurately calculated but which were estimated to be of the right order of magnitude to account for the difference. Using the method of Colburn to calculate individual pressure drops, and then summing these calculated values, it was found that the calculated overall pressure drop for the various configurations varied from 0.93 to 1.27 times the measured overall pressure drop, again the greatest deviations corresponding to the case of low exchanger resistance and significant nozzle effects. It is thus concluded that the method of summing individual pressure drops is satisfactory for the calculation of the overall exchanger pressure drop in the non-leakage exchanger.

Heat transfer results for nine combinations of baffle spacing and cutdown in both the laminar and turbulent regimes in a non-leakage exchanger have been reported.[9]

FIG. 4. Plot of ϕ vs r at $\left(\frac{S_m}{S_w}\right)^{0.03} = 1$.



ABOUT THE AUTHOR

KENNETH J. BELL, assistant professor of chemical engineering at Case Institute of Technology, Cleveland, Ohio, is a specialist in the field of fluid dynamics and heat transfer in nuclear reactors and process equipment. His experience includes service as an engineer with the heat transfer unit, pile engineering, in General Electric's Hanford Atomic Products operation, Richland, Washington. He is also a specialist with D. Q. Kern Associates, Cleveland; a consultant for Thompson Ramo Wooldridge, Inc., and was a visiting faculty member at the Oak Ridge School of Reactor Technology in 1958. Bell holds a BS degree from Case and MChE and PhD degrees from the University of Delaware.

A preliminary attempt at correlation of these data is presented in the same paper. Brown[11] has suggested a better means of correlation not previously published in the general technical literature and which will be considered at some length here. For an exchanger with more than three or four baffles we may write with small error

$$h_{NL}A = h_B A_B + h_w A_w$$

Defining $r = \frac{A_w}{A}$, this equation may be rewritten

$$h_{NL} = h_B (1 - r) + h_w r \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

For ideal tube banks in the turbulent regime, it is found[4,12] that

$$h_B = b\, V_m^{0.6} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

where b is a constant depending on tube bank geometry and fluid properties.

In order to write a similar equation for h_w it is necessary to define an appropriate velocity. Based on plausibility arguments we may assume that h_w is similarly related to the geometric mean velocity V_g. Then we may write

$$h_w = \beta V_g^{0.6} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

and from Equation 5

$$h_{NL} = b\, V_m^{0.6} (1 - r) + r\beta V_g^{0.6} \quad . \quad . \quad . \quad . \quad . \quad (8)$$

We may now make a series of substitutions:

$$V_g^{0.6} = V_w^{0.3} V_m^{0.3}$$

$$V_w^{0.3} = V_m^{0.3} \left(\frac{S_m}{S_w}\right)^{0.3}$$

Hence

$$V_g^{0.6} = V_m^{0.6} \left(\frac{S_m}{S_w}\right)^{0.3}$$

and from Equation 8

$$h_{NL} = b\, V_m^{0.6} \left[(1 - r) + \frac{r\beta}{b} \left(\frac{S_m}{S_w}\right)^{0.3} \right] . \quad (9a)$$

or

$$h_{NL} = \phi\, b\, V_m^{0.6} = \phi\, h_B \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9b)$$

where

$$\phi = (1 - r) + \frac{r\beta}{b} \left(\frac{S_m}{S_w}\right)^{0.3} . \quad . \quad . \quad . \quad (9c)$$

In the turbulent regime the points clearly fall into groups depending upon the baffle cutdown. The smaller the baffle cut, the greater the overall heat transfer coefficient (for a given crossflow velocity). Let I be the value of h_{NL} when $V_m = 1$ ft per sec for each of the nine baffle configurations studied by Brown. Then from equations 9b and 9c

$$I = b\,\phi = b(1 - r) + r\beta \left(\frac{S_m}{S_w}\right)^{0.3}$$

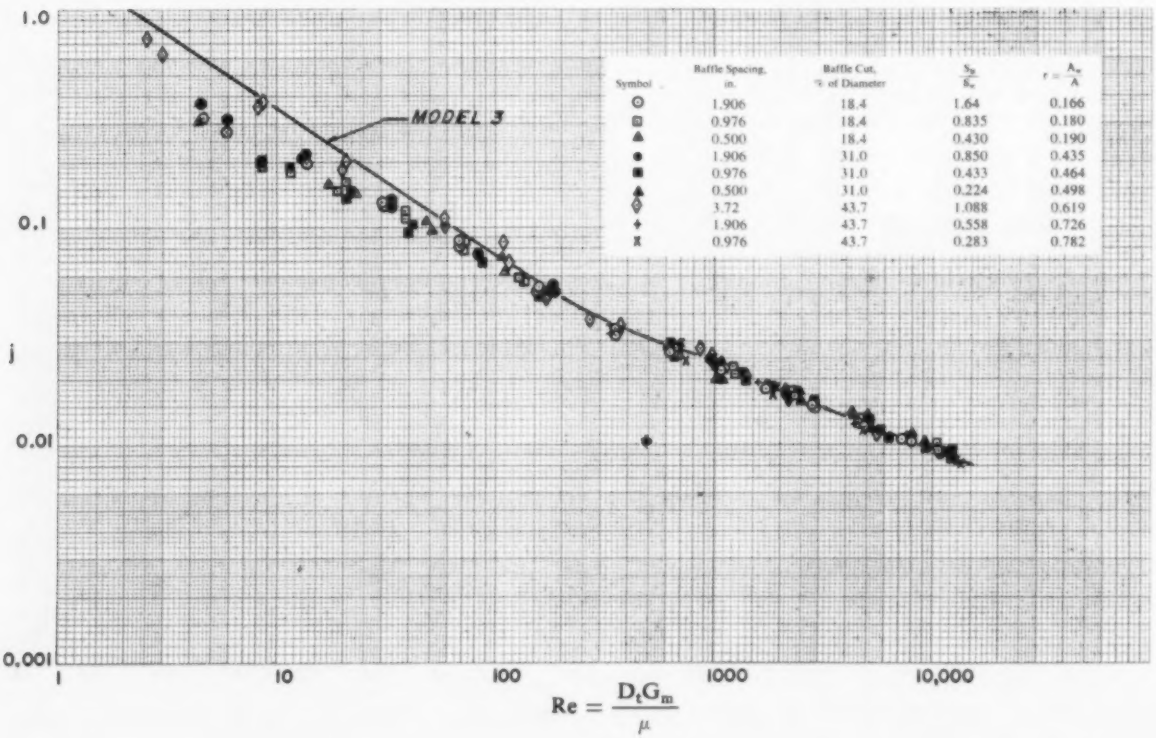
or

$$\beta = \frac{I - b(1 - r)}{r \left(\frac{S_m}{S_w}\right)^{0.3}} \quad . \quad . \quad . \quad . \quad . \quad (10)$$

For each configuration r and S_m/S_w are known, and I can be read from Brown's experimental data lines, and β may then be calculated and correlated versus r and S_b/S_w. Brown finds for his exchanger.

$$\beta = 108 \left(\frac{S_m}{S_w}\right)^{-0.27} r^{-0.68} \quad . \quad . \quad . \quad (11)$$

FIG. 5. Correlation of $j = \left(\frac{h_{NL}\chi_t}{\phi \xi_h c G_m}\right)\left(\frac{c\mu}{k}\right)^{2/3}\left(\frac{\mu_s}{\mu}\right)^{0.14}$ vs Re Model 9.



and the value of b is found to be 205[12]. Substituting these results into equation 9a we have

$$h_{NL} = 205V_m^{0.6}\left[1 - r + 0.524\, r^{0.32}\left(\frac{S_m}{S_w}\right)^{0.03}\right]$$

or

$$\frac{h_{NL}}{\phi} = h_B \quad . \quad . \quad . \quad . \quad . \quad (12a)$$

where

$$\phi = 1 - r + 0.524\, r^{0.32}\left(\frac{S_m}{S_w}\right)^{0.03} \quad . \quad . \quad (12b)$$

Since ϕ is found to be so weak a function of S_m/S_w, the term $(S_m/S_w)^{0.03}$ is taken to be 1 for all cases of reasonable interest and ϕ is given as a function of r in Fig. 4. Before correlating the baffled exchanger turbulent flow results against those for the ideal tube tank, the problem of bypassing and number of rows must be considered. Estimating ξ_h from equation 2 for $F_{BP} = 0.05$ indicates that bypassing resulted in perhaps a 6% decrease in h_o compared to the no-bypass case. On the other hand, if it is assumed that the flow in the baffled exchanger over the range of Brown's tests is in fully developed turbulence, the measured overall coefficient should be increased 5 or 6% compared to that for the 14 tube rows of Model 3. In short, we expect that the bypassing effect and the number of tube rows effect should essentially cancel out for Brown's data, but they should both be considered and evaluated for each individual case. Therefore, the correlating group to be used in comparing baffled exchangers with bypass but no baffle leakage to ideal tube bank results is $\frac{h_{NL}\chi_t}{\phi\xi_h}$.

In Fig. 5 Brown's results correlated on the basis of $j = \left(\frac{h_{NL}\chi_t}{\phi\xi_h c\, G_m}\right)\left(\frac{c\mu}{k}\right)^{2/3}\left(\frac{\mu_s}{\mu}\right)^{0.14}$ fall within −10 to +20% of the curve for Model 3, the ideal tube bank. The limited turbulent data of Knowles[9] confirm the validity of Brown's method of analysis in the turbulent flow regime.

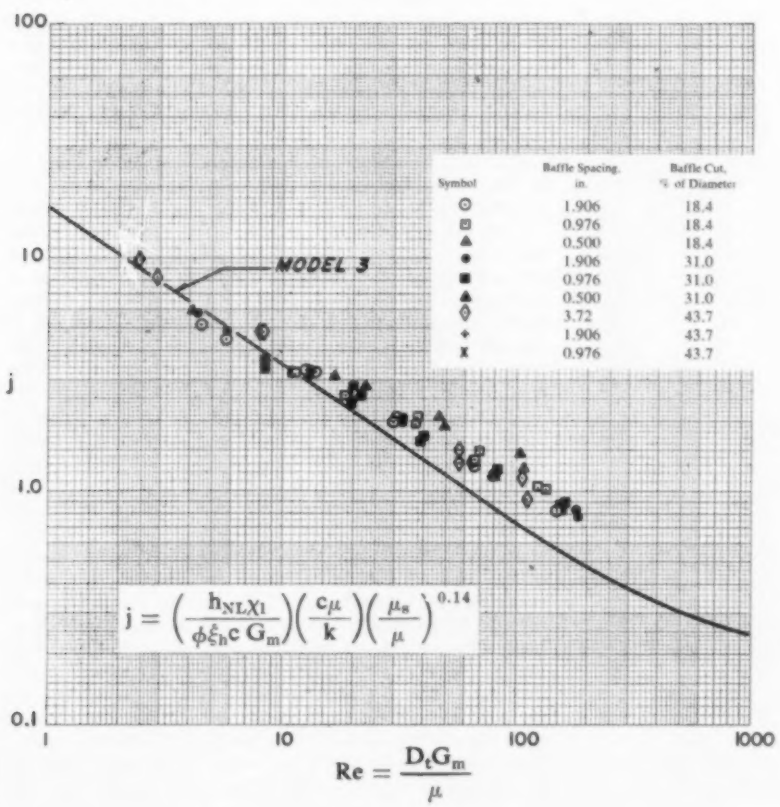
In the laminar flow regime the experimental results on Model 9 due to Tompkins are more scattered and do not show the well-defined variation with baffle configuration that the turbulent regime results do. For the sake of consistency Tompkins' results have been correlated on the same basis as the turbulent flow results in Fig. 5. They are found to be in good agreement for Re > 100 but fall 0 to 50% below the results of the corresponding ideal tube bank (Model 3) at lower Reynolds numbers. In view of the previously mentioned dependence of j on the number of tube rows in the laminar regime, it is appropriate to examine this further. Define the total effective number of cross-flow tubes in series in the exchanger to be:

$$N'_c = (N_b + 1)\, N_c + (N_b + 2)N_w \quad . \quad . \quad . \quad (13)$$

From the ideal tube bank results quoted above, $j \sim N_c^{-0.18}$, assume for the present that this relation holds for the baffled exchanger. Hence, to compare results for Model 3 ($N_c = 13$) and the baffled exchanger, the usual j factor for the latter must be multiplied by

$$\chi_l = \left(\frac{N'_c}{13}\right)^{0.18} \quad . \quad . \quad . \quad . \quad . \quad . \quad (14)$$

for the number of rows effect and divided by ξ_h (defined by equation 2) for the bypass effect. Division by ϕ as de-



Symbol	Baffle Spacing, in.	Baffle Cut, % of Diameter	S_b/S_w	$r = A_w/A$
⊙	1.906	18.4	1.64	0.166
⊡	0.976	18.4	0.835	0.180
▲	0.500	18.4	0.430	0.190
●	1.906	31.0	0.850	0.435
■	0.976	31.0	0.433	0.464
▲	0.500	31.0	0.224	0.498
◊	3.72	43.7	1.088	0.619
✦	1.906	43.7	0.558	0.726
X	0.976	43.7	0.283	0.782

FIG. 6. Correlation of j vs Re valid at low Reynolds numbers, Model 9.

Symbol	Clearances: Tube-baffle, in.	Shell-baffle, in.	S_L, ft²	S_m, ft²
+	0.006	0	0.00181	0.0210
x	0.013	0	0.00392	0.0210
●	0	0.021	0.000881	0.0210
■	0	0.063	0.00264	0.0210
▲	0	0.133	0.00559	0.0210

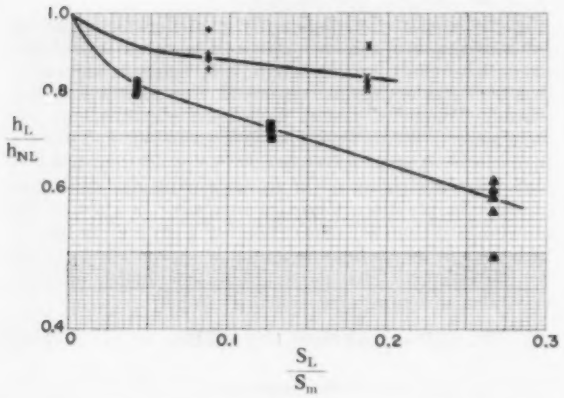


FIG. 7a. Effect of tube-to-baffle and shell-to-baffle clearances on overall shell-side heat transfer coefficient in Model 9.

Symbol	Clearances: Tube-baffle, in.	Shell-baffle, in.	S_L, ft²	S_m, ft²
+	0.006	0	0.00181	0.0210
x	0.013	0	0.00392	0.0210
●	0	0.021	0.000881	0.0210
■	0	0.063	0.00264	0.0210
▲	0	0.133	0.00559	0.0210

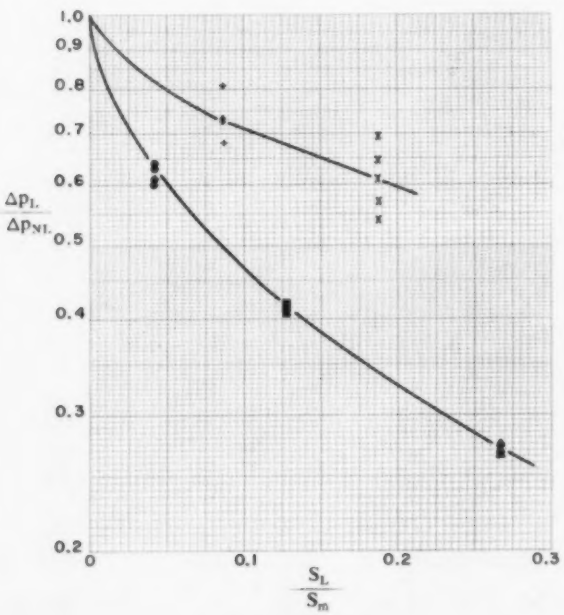


FIG. 7b. Effect of tube-to-baffle and shell-to-baffle clearances on overall shell-side pressure drop in Model 9.

fined by equation 12b is retained even though its application without modification is questionable.

In Fig. 6, Tompkins' data are replotted on the basis of $j = \left(\frac{h_{NL}\chi_l}{\phi\,\xi_h\,c\,G_m}\right)\left(\frac{c\mu}{k}\right)^{2/3}\left(\frac{\mu_s}{\mu}\right)^{0.14}$. Results for the baffled exchanger now fall within ±15% of the ideal tube bank curve at Reynolds numbers below 15, suggesting that the above argument has some merit. At higher Reynolds numbers the points scatter more and fall above the ideal curve. This behavior indicates that at higher Reynolds numbers, the adverse temperature structure is at least partially destroyed by mixing in the turnarounds. It would not be difficult to obtain an empirical equation for a curve which would fall through the points and give the proper limiting cases at very low and high Reynolds numbers. To do so would suggest undue reverence to a frankly tentative and possibly fortuitous argument. Rather, in the intermediate range, it is better to calculate the limiting values and evaluate the consequences before interpolating.

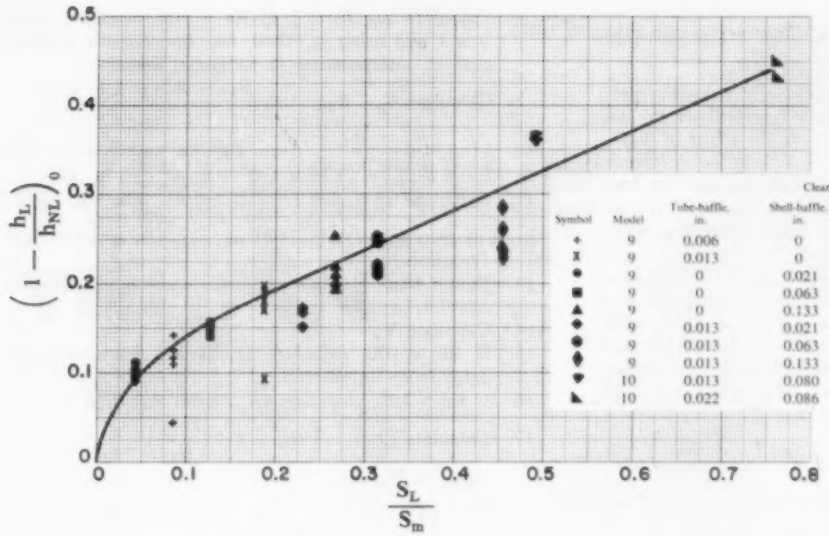
On the basis of the available data the design of non-leakage exchangers in the turbulent flow regime can be entered into with some confidence by the method proposed here. The situation in the laminar flow regime is not as satisfactory and will require extensive additional experimental work to firm up the correlation.

The effect of baffle leakage

The next step in the Delaware project was to examine the effect of clearances between the baffle and the shell and between the tubes and the baffle. Pressure drops exist across these clearances, and consequently there is flow from one baffle section to the next. In effect, part of the shell-side flow is short-circuited, decreasing local velocities and consequently decreasing pressure drops and heat transfer coefficients compared to the corresponding baffle non-leakage exchanger. Also, the leakage streams have a temperature corresponding to conditions upstream of the baffle across which they leak and consequently distort temperature profiles in the stream into which they are leaking. It is necessary to distinguish between the effects of the tube-to-baffle leakage streams and that of the shell-to-baffle leakage streams.

The tube-to-baffle leakage streams flow along the tube in the immediate vicinity of the baffle at a fairly high velocity and hence involve a heat transfer process of significant magnitude on the outside of the tube. The orifice-baffle heat exchanger makes use of this mechanism. In effect, this type of exchanger is nothing but a sequence of baffles with leakage areas around the tubes. The shell-to-baffle leakage stream on the other hand does not come in contact with heat transfer surface in its path and consequently represents a significant loss to the efficiency of the heat transfer process.

Much of the Delaware data relating to the effects of baffle leakage streams is reported in Reference[18], in which it is concluded that baffle leakage has a far greater effect upon pressure drop than it does upon heat transfer. It is also concluded that leakage area between the baffle and the shell has a greater effect upon the heat transfer coefficient and upon pressure drop than does a corresponding amount of leakage area around the tubes. In one particular case it was even noted that increasing the leakage area by increasing the tube-to-baffle clearance while leaving the shell-to-baffle clearance constant resulted in an increased overall heat transfer coefficient and the expected decrease in pressure drop. This is understandable when one considers that the tube-to-baffle leakage stream, which was enhanced in the second experiment compared to the first, has a significant heat transfer efficiency which more than overcame (in this particular case) the effect of an increase in total



Symbol	Model	Clearances: Tube-baffle, in.	Clearances: Shell-baffle, in.	S_{tb}, ft²	S_{sb}, ft²	S_m, ft²
♦	9	0.006	0	0.00181	0	0.0210
x	9	0.013	0	0.00392	0	0.0210
●	9	0	0.021	0	0.000881	0.0210
■	9	0	0.063	0	0.00264	0.0210
▲	9	0	0.133	0	0.00559	0.0210
◆	9	0.013	0.021	0.00392	0.000881	0.0210
⬢	9	0.013	0.063	0.00392	0.00264	0.0210
⧫	9	0.013	0.133	0.00392	0.00559	0.0210
▼	10	0.013	0.080	0.0154	0.00527	0.0424
◣	10	0.022	0.086	0.0263	0.00566	0.0421

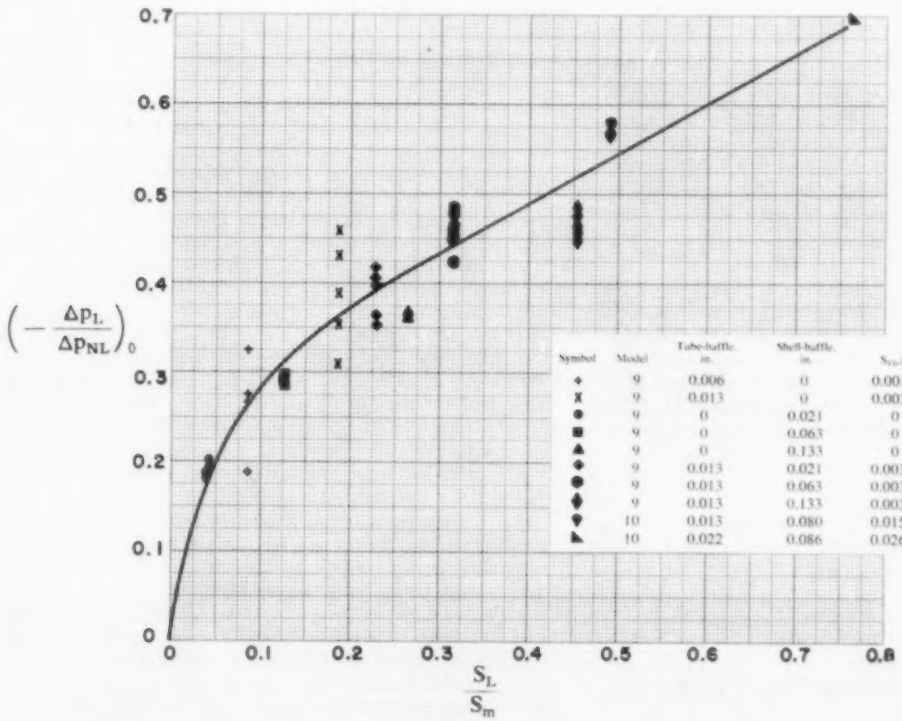
FIG. 8a. Effect of baffle leakage on overall shell-side heat transfer coefficient.

leakage. In that paper it was found that for reasonable clearances the pressure drop may be reduced to 25% and the heat transfer coefficient may be reduced to 50% of the non-leakage values.

To be useful for designing purposes these results must be interpretable quantitatively. Sullivan[14] obtained an analytical solution of the effect of leakage upon pressure drop using an idealized single baffle exchanger (Model 8) to verify his mathematical model. His analysis was also extended to the case of a multi-baffle exchanger. The results of his analysis apply to the pressure drop; and inasmuch as they are rather complex they are not especially useful for the usual purposes of the design engineer. However, a consequence of Sullivan's work was to show that the form of a correlating variable for leakage effects is

$$\frac{S_L C_L}{S_m} (fN_c)^{1/2} \left(\frac{\delta p}{\Delta p_B}\right)^{1/2}$$

where S_L is the leakage area per baffle, C_L is a weighted orifice coefficient for the leakage paths, δp is the mean pressure difference across a baffle, and S_m, f, N_c, and Δp_B have their usual definitions. This group is readily interpretable in physical terms: the product $S_L C_L (\delta p)^{1/2}$ is a measure of the rate of flow through the leakage areas, and the



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◣	10	0.022	0.086	0.0263	0.00566	0.0421

FIG. 8b. Effect of baffle leakage on overall shell-side pressure drop.

group $\frac{S_m(\Delta p_B)^{1/2}}{(fN_c)^{1/2}}$ is a measure of flow across the tube bank between the baffles.

The Sullivan group was employed in a correlation proposed in Reference[12]. The correlation is tedious to use. Worse, though it does properly indicate the effect of Reynolds number on leakage, it does not reflect the difference between shell-to-baffle and tube-to-baffle leakage on heat transfer. The definition of C_L could be changed to at least partially correct this, but it appears more rewarding at the present to pursue a simpler approach.

Some studies[9] were made on the effects of each leakage path alone on h and Δp. Results are shown in Fig. 7a and 7b. The abcissa is the ratio of total leakage area per baffle to minimum crossflow area per baffle section. As indicated above the tube-to-baffle leakage affects h and Δp less than does the shell-baffle leakage for the same relative leakage area, and h is less affected by leakage than is Δp. Very roughly, at given $\frac{S_L}{S_m}$, $\left(1-\frac{h_L}{h_{NL}}\right)$ and $\left(1-\frac{\Delta p_T}{\Delta p_{NL}}\right)$ for tube-to-baffle leakage are about half the values of shell-to-baffle leakage. Hence, a single curve of $1-\left(\frac{h_L}{h_{NL}}\right)_o$ vs S_L/S_m is obtained if the values of $\left(1-\frac{h_L}{h_{NL}}\right)$ for shell-to-baffle leakage only are divided by 2 and the values of $\left(1-\frac{h_L}{h_{NL}}\right)$ for tube-to-baffle leakage are divided by 1. For the case of exchangers having both leakage paths, assume that the effects of the leakages are additive if each leakage is weighted by its corresponding area, i.e.,

$$\left(1-\frac{h_L}{h_{NL}}\right)_{Exchanger}=\left(1-\frac{h_T}{h_{NL}}\right)_o\left[\frac{S_{TB}+2\,S_{SB}}{S_L}\right] \quad (15)$$

where $S_L = S_{TB} + S_{SB}$. The same result is found for the pressure drop:

$$\left(1-\frac{\Delta p_L}{\Delta p_{NL}}\right)_{Exchanger}=\left(1-\frac{\Delta p_T}{\Delta p_{NL}}\right)_o\left[\frac{S_{TB}+2\,S_{SB}}{S_L}\right] \quad (16)$$

All of the exchanger leakage results of the Delaware project are plotted on this basis in Fig. 8a and 8b. The agreement is no better than might be expected, but the method has the virtue of simplicity. It should be noted that it is not possible to show all of the points used in Fig. 7a, 7b, 8a, and 8b. Extreme points for each S_L/S_m show the total range of experimental points.

Design procedure

For purposes of shell-side design calculations, the foregoing discussion may be systematized into the following steps. It is assumed as a prerequisite that complete information of the shell-side geometry and the shell-side fluid properties are available. It is also assumed that f and j curves are available for the ideal tube bank geometry corresponding to the shell-side tube layout:

1. Calculate $Re = \frac{D_t G_m}{\mu}$
2. Find j from j vs Re curve for ideal tube bank.
3. Calculate the minimum F_{BP} for the crossflow sections.
4. Calculate ξ_h from Equation 2.
5. Find ϕ from Fig. 4.
6. If Re <100 calculate N'_c from Equation 13.
7. Find χ_t (Re > 2000) or χ_l(Re < 100) from Table 3 or Equation 14, respectively. For $100 <$ Re < 2000, use $\chi = 1$.
8. Calculate h_{NL} from j. If Re <100, calculate using $\chi = 1$ and using χ_l, then use appropriate limiting case or interpolation as judgment suggests.
9. Calculate S_{TB}, S_{SB}, and $\frac{S_{TB}+2\,S_{SB}}{S_L}$.
10. Find $\left(1-\frac{h_L}{h_{NL}}\right)$ from Fig. 8a, and Equation 15.
11. Calculate h_L from $\left(1-\frac{h_L}{h_{NL}}\right)^{Exchanger}$.
12. Calculate $\xi_{\Delta p,t}$ (Re > 100) or $\xi_{\Delta p,l}$ (Re < 100) from Equation 2.
13. Find f from f vs Re curve for ideal tube bank and calculate Δp_{BP}.
14. Calculate V_w.
15. If Re <100, calculate D_v (from definition) and $\Delta p_{w,l}$ from Equation 3.
16. If Re >100, calculate $\Delta p_{w,t}$ from Equation 4.
17. Calculate $\Delta p_{NL}=\left(N_B+1+\frac{2N_w}{N_c}\right)\Delta p_{BP}+N_B\,\Delta p_w$.
18. Find $\left(1-\frac{\Delta p_L}{\Delta P_{NL}}\right)_{Exchanger}$ from Fig. 8b, and Equation 16.
19. Calculate Δp_L from $\left(1-\frac{\Delta p_L}{\Delta p_{NL}}\right)_{Exchanger}$.

General design rules

The foregoing design procedure is suited to the problem of rating exchangers, that is, determining the suitability of a given exchanger to carry out a given job. The general procedure for exchanger rating is to start with the smallest or least expensive exchanger which it is thought may succeed in carrying out the required heat transfer and to determine whether in fact it will do so. The rating procedure is continued for other sizes of exchangers until an exchanger is found which is calculated to do the job at the least cost.

A problem of equal interest and importance is to design in part, or in toto, an exchanger specifically to do a given job. This latter problem would most likely arise in the case of a large required service in which the possible savings in apparatus cost would more than compensate for the added time involved in design and special machining and construction of the exchanger. For this purpose the procedure suggested above is not especially satisfactory; nor are other present methods of exchanger design particularly suited to this problem. Ideally, what would be desired here would be an analytical statement of exchanger performance as a function of all of the independent design variables of the exchanger and fluid properties. The optimum design — that which solves the required heat transfer problem at the lowest annual cost of exchanger and associated apparatus — would then be found by solution of the analytical performance equations to give the minimum cost. Such a procedure is at this time impossible because of lack of knowledge of the analytical expressions required to completely define exchanger performance and the difficulty of solving these equations for the optimum configuration even if the equations were available. It is, however, possible to make certain statements regarding certain design variables which will at least somewhat limit the manifold of possibilities of exchanger designs to meet a given service.

1. It may be stated that on the basis of heat transfer coefficient obtained for a given amount of pumping power expended per square foot of heat transfer service that staggered tube arrays with small pitch ratio are in general slightly more efficient than staggered arrays with large pitch ratio or inline arrays. The inline arrays are particularly inefficient in the transition Reynolds number regime.

2. On the basis of heat transfer coefficient obtained for a given pumping power expended per unit area, it is found

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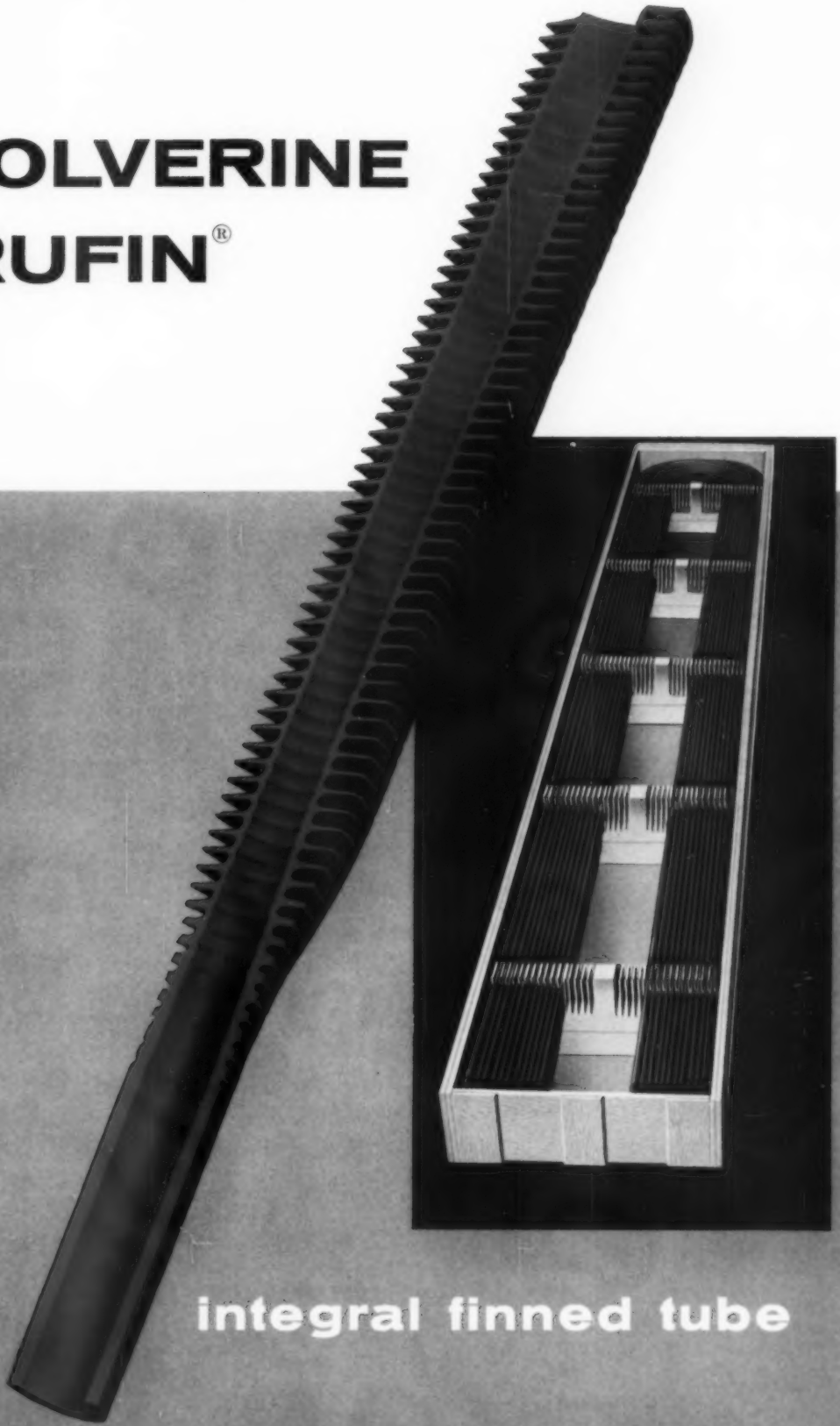

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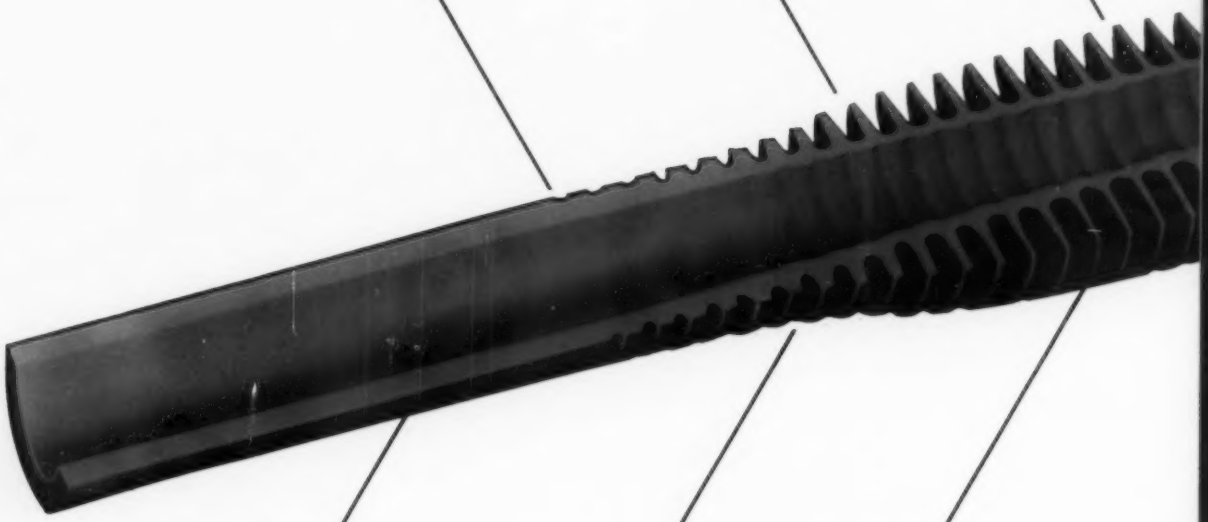

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that all baffle configurations and all leakage and bypass conditions are inferior to that of the ideal tube bank. From this it follows that, insofar as possible, and within certain limitations to be discussed below, leakage and bypass flow should be minimized and the exchanger configuration approach as closely as possible to the ideal tube bank. Rigorous application of this principle would lead to excessive pumping power losses in the baffle turnarounds. In the light of available evidence, the optimum case seems to be that in which the velocity through the window is about equal to the maximum velocity through the tube bank.

3. By far the most serious loss of efficiency in the operation of a typical exchanger is bypass around the tube bundle between the bundle and shell. In any case this bypass stream must be minimized by designing the clearance between the tube bundle and the shell to be as small as possible. For exchanger designs such as the pull-through floating head type, which require a significant clearance, seal-strips should be inserted between the shell and the outermost row of tubes at two or three or even more points along the flow path in each crossflow section. To be most effective, these strips must block the entire bypass channel.

4. The next most serious loss of efficiency is due to leakage between the baffle and the shell. The shell and baffle system should be carefully designed and manufactured so as to keep this clearance to the absolute minimum required for insertion and removal of the tube bundle. Some manufacturers go so far as to bore the inside of the shell or expand it over a mandrel to bring the shell as close to a true circular cylinder as possible and thereby minimize the shell-to-baffle clearance.

5. The least serious of the leakage and bypass streams is the tube-to-baffle leakage stream. In general this stream should be minimized, but not if by so doing the shell-to-baffle leakage stream is substantially enhanced. In general, the leakage area between the tubes and baffle should be greater than that between the baffle and the shell.

6. Since the entire flow passes across essentially the entire tube bundle in the two end crossflow sections in contrast to the internal crossflow sections, the end sections should have a substantially larger baffle spacing than the internal ones.

Illustrative example

This example is not a complete design problem, but is intended to display the method of design proposed in this paper and to clarify definitions. It also seemed desirable for purposes of comparison to work with an exchanger whose performance was known. The design procedure will be applied to a later test exchanger configuration of the Delaware project designated as 10-TL3, whose dimensions are given in Table 4. There are no seal strips. The shell-side fluid is Gulf 896, 23,600 lb per hr at 140.0 F in and 159.0 F out. The tube side was water in at 175.5 F and 173.7 F. The tests on this configuration were not employed to develop the correlations presented here and hence represent a semi-independent check on the method.

1. Viscosity of Gulf 896 at 149.5 F is 4.50 lb per ft hr. The tube rows immediately above and below the centerline have 24 tubes each. Therefore

$$S_m = \frac{[8.502 - 24(0.249)]\ 2.643}{144} = 0.0460\ \text{ft}^2$$

and

$$Re = \frac{(0.25)\ (23{,}600)}{(12)\ (0.0460)\ (4.50)} = 2380$$

2. From Fig. 2, by interpolation between curves 1 and 4,

$$j = 0.0170 = \left(\frac{h_{NL}\,\chi_t}{\phi\,\xi_b\,c\,G_m}\right)\left(\frac{c\mu}{k}\right)^{2/3}\left(\frac{\mu_s}{\mu}\right)^{0.14}.$$

TABLE 4. Exchanger 10-TL3: Exchanger Dimensions.

Tube array	Equilateral triangle
Tube-baffle clearances, on diameter, in.	0.013
Shell-baffle clearances, on diameter, in.	0.080
OD baffles, in.	8.422
ID shell, in.	8.502
Baffle edge, in.	6.50
Baffle cut-down, %	17.56
Baffle hole diameter, in.	0.2623
Baffle spacing, in.	2.643
Baffle thickness, in.	0.0625
Number of baffles	5
No. tubes in each window	46
No. tubes plus spacers in window	49
No. tubes in crossflow	378
OD tubes, in.	0.2493
Effective tube length, in.	16.125
Distance between tube centers, in.	0.34375
Pitch	1.33
Distance between tubes, in.	0.0944

3. Evaluate F_{BP} at the 24-tube rows: The diametral clearance between the outer tubes and the shell is $8.502 - 23\ (1.33)\ (0.249) - 0.249 = 0.64$ in.

Then $F_{BP} = \dfrac{0.64\ (2.643)}{144\ (0.0460)} = 0.255$

4. From Equation 2

$\xi_b = e^{-1.25\ (0.255)} = 0.728$

5. To an excellent approximation, r is the ratio of the number of tubes in both upper and lower windows (92) divided by the total number of tubes (470), i.e., $r = 0.196$. From Fig. 4, $\phi = 1.11$.

6. Skip, since $Re > 100$.

7. There are 18 rows in each crossflow section; the j factor plot (Fig. 2) is based on 10 rows. From Table 2, $\chi_t = \dfrac{0.96}{0.93} = 1.03$.

8. For Gulf 896 at 149.5 F, $c = 0.526$ Btu per lb F and $\left(\dfrac{c\mu}{k}\right)^{2/3} = 9.55$.

Also estimate $\left(\dfrac{\mu_s}{\mu}\right)^{0.14} = 0.97$; in principle, this quantity must be found by trial-and-error. Then

$$h_{NL} = \frac{0.0170(1.11)(0.728)(0.526)(23{,}600)}{1.03 \qquad (0.0460)(9.55)(0.97)}$$
$$= 389\ \text{Btu/(hr)(ft}^2\text{)(F)}$$

9. Calculate S_{TB} observing that each baffle has $(378 + 46) = 424$ tubes.

Then $S_{TB} = \dfrac{424}{144}\left(\dfrac{\pi}{4}\right)(0.2623^2 - 0.2493^2) = 0.0154\ \text{ft}^2$.

Calculate S_{SB} assuming that the baffle is concentric to the shell. The angle subtended by the baffle cut is $2\ \text{Sin}^{-1}\dfrac{6.360}{8.422} = 98°$.

Then

$$S_{SB} = \left(\frac{360\text{-}98}{360}\right)\frac{\pi}{4}\left(\frac{8.502^2 - 8.422^2}{144}\right) = 0.00539\ \text{ft}^2$$

$$S_L = S_{TB} + S_{SB} = 0.0208$$

$$\frac{S_{TB} + 2S_{SB}}{S_L} = 1.26;$$

10.

$$\frac{S_L}{S_m} = \frac{0.0208}{0.0460} = 0.453$$

From Fig. 8a, $\left(1-\frac{h_L}{h_{NL}}\right)_0 = 0.30$

and from Equation 15 $\left(1-\frac{h_L}{h_{NL}}\right)_{Exchanger} = 0.30(1.26) = 0.378$

11. Then $\frac{h_L}{h_{NL}} = 0.622$ and finally

$$h_L = 0.622(389) = 242\ \frac{Btu}{(hr)(ft^2)(F)}$$

12. From Equation 2

$$\xi_{\Delta p,t} = e^{-3.8(0.255)} = 0.380$$

13. From Fig. 2 by interpolation,

$$f = 0.17 = \left[\frac{2\ \Delta p_{BP}\ g_c \rho}{4\ \xi_{\Delta p,t} G_m^2}\right]\left(\frac{\mu}{\mu_s}\right)^{0.14}$$

or

$$\Delta p_{BP} = \frac{0.17\ (4)(0.380)\ (23{,}600)^2\ (18)(0.97)}{2\ (32.2)\ (3600)^2\ (0.0460)^2\ (49.0)}$$

or

$$\Delta p_{BP} = 29.1\ \frac{lbf}{ft^2}$$

$\left(\rho \text{ for Gulf 896 at } 149.5F = 49.0\ \frac{lbm}{ft^3}\right)$

14. The window flow area S_w may be calculated as

$$S_w = \frac{\pi}{144}\left(\frac{8.502}{2}\right)^2\left(\frac{98}{360}\right) - \left(\frac{8.502}{2}\right)^2\frac{(\sin 98^\circ)}{(2)(144)}$$

$$-49\left(\frac{\pi}{4}\right)\left(\frac{0.249}{144}\right)^2 = 0.0289\ ft^2$$

$$V_w = \frac{23{,}600}{0.0289\ (49.0)\ (3600)} = 4.65\ ft\ per\ sec$$

$$V_m = \frac{23{,}600}{0.0460\ (49.0)\ (3600)} = 2.91\ ft\ per\ sec$$

$$V_g = \sqrt{4.65\ (2.91)} = 3.68\ ft\ per\ sec$$

15. Skip, since Re >100.

16. From a tube layout, it is found that there are five tube rows between the baffle cut and the shell. The outer two, however, have less than half the tubes of the centerline rows (4 and 11 respectively) so $N_w = 3$. From Equation 4

$$P_{w,t} = [2 + 0.6(3)]\ \frac{(49)\ (3.68)^2}{2(32.2)}$$

$$= 39.2\frac{lbf}{ft^2}$$

17. Because the two end sections will have substantially higher pressure drops than the internal sections and there are only five baffles, it is desirable to modify the last three steps. Treat the two end crossflow sections as non-leakage sections. Then the pressure drop in each end crossflow section is $\left(1+\frac{N_w}{N_c}\right)\ \Delta p_{BP}$ or $1.167\ (29.1) = 34.0\ lbf/ft^2$. The non-leakage pressure drop for the remainder of the exchanger is

$$4(29.1) + 5(39.2) = 312.4\ lbf/ft^2$$

18. From Fig. 8b at $S_L/S_m = 0.453$,

$$\left(1-\frac{\Delta p_L}{\Delta p_{NL}}\right)_0 = 0.51$$

and

$$\left(1-\frac{\Delta p}{\Delta p_{NL}}\right)_{Exchanger} = 0.51(1.26) = 0.643$$

19. Then the pressure drop for the entire exchanger, Δp_L is $2(34.0) + 0.357(312.4) = 176\ lbf/ft^2$ or $\Delta p_L = 1.22\ lbf/in.^2$

Experimental results gave $h_L = 264$ Btu/(hr)(ft²)(F) compared to the calculated 242, an error of 8.3%, and $\Delta p_L = 1.30\ \frac{lbf}{in.^2}$ compared to the calculated 1.22, an error of 6.2%.

Acknowledgment

The author wishes to acknowledge the many valuable suggestions and general guidance of the entire program by the ASME Special Advisory Committee of the Heat Transfer Division which sponsored this cooperative research project. The committee during the course of the project included: chairman, A. C. Mueller, succeeding W. H. McAdams; C. H. Brooks, A. P. Colburn, A. Y. Gunter, S. Kopp, W. N. McCurdy, Jr., B. E. Short, W. H. Thompson, T. Tinker, P. R. Trumpler, and G. H. VanHengel. The help of A. Wurster in the design and construction of the test units was invaluable. Funds and equipment were furnished by the American Petroleum Institute, the Tubular Exchanger Manufacturer's Association, Andale Company, Davis Engineering Company, Downingtown Iron Works, E. I. du Pont de Nemours and Company, Standard Oil Development Company, and York Ice Machinery Company. The various test oils were provided by the Gulf Oil Corporation. The experimental studies were carried out over a number of years by research fellows at the University of Delaware. The contributions of H. L. Hull, F. W. Sullivan III, G. A. Brown, and M. D. Leighton were particularly significant and definitive.

The author makes a special note of professional and personal indebtedness in this work to Dr. Olaf P. Bergelin and the late Dr. Allan P. Colburn, who initiated the project and guided it through all of the years in which active experimental work was underway. Beside the easily attributable contributions that each of these men made to the work at hand, a particular debt is due them for their insistance upon combining understanding of fundamental mechanisms and inspired insight and art, which are essentials of any heat transfer design procedure today.

Nomenclature

The units shown are consistent; any other consistent set will do as well.

- A = Total shell-side area for heat transfer, ft².
- A_B = Shell-side heat transfer area of tubes in one crossflow section, ft².
- A_w = Shell-side heat transfer area of tubes in one window section, ft².
- b = Coefficient in Equation 6, (Btu) (sec$^{0.6}$)/(hr) (ft$^{2.6}$) (F).
- c = Specific heat of shell-side fluid, $\frac{Btu}{lbm\ F}$.
- D_t = Tube diameter, ft.
- D_v = Volumetric equivalent diameter of the window, ft.

$$D_v = \frac{4\ S_w L_B}{A_w}$$

- F_{BP} = Fraction of total minimum crossflow area that is in the bypass channel between bundle and shell, dimensionless.
- f = Crossflow friction factor for ideal tube bank defined by

$$f = \frac{2\ \Delta p_B\ g_c\ \rho}{4\ G_m^2\ N_c}\left(\frac{\mu}{\mu_s}\right)^{0.14} \text{ dimensionless.}$$

A slightly different definition involving bypass correction is used and indicated in the correlation.

G_m = Mass velocity based on S_m, lb per sec ft².

g_c = Gravitational conversion constant,

$$32.2\ \frac{\text{lbm ft}}{\text{lbf hr}^2}$$

h = Heat transfer coefficient, Btu per hr ft² F; h_B, coefficient for crossflow section or ideal tube bank, no bypass or leakage; h_{BP}, coefficient for crossflow section or overall coefficient for the exchanger, after bypass correction, no leakage. h_L, overall coefficient for the exchanger with bypass and leakage; h_m, mean coefficient for tube bank of finite number of rows; h_{NL}, overall coefficient for the exchanger with no bypass or leakage; h_w, coefficient for a window section, no bypass or leakage; h_z, coefficient for an ideal tube bank with an infinite number of tube rows, turbulent flow.

I = Value of h_B at $V_m = 1$ ft per sec,

$$\frac{\text{Btu}}{(\text{hr})(\text{ft}^2)(\text{F})}$$

j = Colburn heat transfer factor defined by

$$j = \left(\frac{h_B}{c\,G_m}\right)\left(\frac{c\mu}{k}\right)^{2/3}\left(\frac{\mu_s}{\mu}\right)^{0.14}$$

for ideal tube bank dimensionless.

Slightly different definitions involving exchanger geometry corrections are used and indicated in the correlations.

k = Thermal conductivity of shell-side fluid,

$$\frac{\text{Btu}}{(\text{hr})(\text{ft}^2)(\text{F/ft})}.$$

L_B = Baffle spacing, ft.

m = Empirical exponent, dimensionless.

n = Empirical exponent, dimensionless.

N_B = Number of baffles.

N_c = Number of major constrictions encountered during flow through one crossflow section. N_c is the number of tube rows between baffle tips in inline square or equilateral triangle arrays and one less than the number of tube rows between baffle tips in staggered square arrays.

N'_c = Total effective number of major constrictions encountered during flow through the entire shell side of a baffled exchanger.

N_s = Number of sealing strips encountered during flow across one crossflow section.

N_w = Effective number of restrictions for crossflow in window. N_w is approximately the number of tube rows between the baffle tip and the shell.

P = Tube pitch, the minimum distance between centers of adjacent tubes, ft.

Δp = Pressure drop, lbf/ft². Δp_B, pressure drop for crossflow section or ideal tube bank, no bypass or leakage; Δp_{BP}, pressure drop for crossflow section or entire exchanger, after bypass correction, no leakage; Δp_L, overall pressure drop for the exchanger with bypass and leakage; Δp_{NL}, overall pressure drop for the exchanger with no bypass or leakage; Δp_w, pressure drop for a window section, no bypass or leakage.

r = Ratio of shell-side heat transfer area in the windows to total heat transfer area $r = A_w/A$, dimensionless.

Re = Reynolds number for crossflow, $Re = \dfrac{D_t G_m}{\mu}$ dimensionless.

s = Minimum spacing between adjacent tubes, $s = P - D_t$, ft.

S_m = Minimum area for crossflow near centerline of exchanger, ft².

S_w = Area for flow through baffle cutdown, ft².

V_m = Crossflow velocity based on S_m, ft per sec.

V_w = Window velocity based on S_w, ft per sec.

V_z = Geometric mean velocity, $V_z = \sqrt{V_m\ V_w}$, ft per sec.

α = Empirical constant in Equation 2.

β = Coefficient in Equation 7, (Btu)(sec)/(hr)(ft$^{2.6}$)(F).

ξ = Correction for bypass flow effects, dimensionless; $\xi_h = \dfrac{h_{BP}}{h_{NBP}}$, correction for heat transfer coefficient; $\xi_{\Delta p,t} = \dfrac{\Delta p_{BP}}{\Delta p_{NBP}}$, correction for crossflow pressure drop in turbulent regime; $\xi_{\Delta p,l} = \dfrac{\Delta p_{BP}}{\Delta p_{NBP}}$, correction for crossflow pressure drop in laminar regime.

μ = Absolute viscosity, lbm per ft sec.

μ_s = Absolute viscosity at heat transfer surface, lbm per ft sec.

ρ = Density of shell-side fluid, lbm per ft³.

ϕ = Correction factor on ideal crossflow heat transfer coefficient for window effects, dimensionless.

χ = Correction factor on ideal crossflow heat transfer coefficient for number of tube rows, dimensionless. χ_t – correction factor for turbulent regime from Table 2; χ_l – correction factor for very low Reynolds numbers from Equation 14.

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★ ★ ★

How to buy heat exchangers

CHARLES H. GILMOUR

MEET THE AUTHOR

Charles H. Gilmour, in charge of engineering research in the engineering department of Union Carbide Chemicals Company, South Charleston, West Virginia, has dealt with problems of design, construction, and testing of heat exchangers for more than a quarter of a century. During the past 15 years practically all of the heat exchangers used by his company have been designed under his supervision. His method of heat exchanger design, which consists of a systematic procedure for arriving at an answer in the minimum of time, has been published. He is author of many articles of a general nature on heat transfer. Gilmour, a chemical engineer, is chairman of the heat exchanger subcommittee of the AIChE equipment testing procedures committee; is member of a subcommittee of the ASA B-78 committee for standardization of heat exchangers for chemical plant use; represents the AIChE on the cooling tower standardization committee; and is a member of the ASME heat exchanger users committee K-10A.

At the combined AIChE-ASME conference in August 1960, he served on the panel which discussed discrepancies between design and performance of heat exchangers. In his close association with the design and testing of heat exchangers he has developed considerable knowledge in various construction techniques and has been able to determine the reasons for failure of heat exchangers to perform. In many cases the failure is not attributable to heat transfer, but rather to methods of installation. The author received his education at Syracuse University, Carnegie Tech, and Massachusetts Institute of Technology.

Times have changed, and the responsibility of the purchasing company's design engineers is clear cut

HEAT EXCHANGERS for use in process plants may be considered to be medium-price, high quality machines. The combined cost of the heat exchangers as a percentage of total plant cost is significant. Because of the large quantity to be purchased, it is desirable that particular attention be paid to procurement of a high-quality, high-performance unit.

Too often, the procurement procedure is operated like a game but one in which neither team wins because each writes and plays according to its own rules. On the one hand the purchaser, who is interested in obtaining a high-quality, high-performance unit, gives the prospective vendor a minimum amount of information on which to design. On the other hand the vendor, who is interested in making and selling a high-quality unit, supplies the purchaser with minimum details of the proposed exchanger. If the prospective vendor gathers enough courage to ask for additional **needed** information he is apt to be looked-on with suspicion by the purchaser. If the purchaser attempts to find out pricing methods or design details, the vendor then becomes suspicious. As a result, negotiations between the two groups, which should be on a cooperative plane, too often develop into a strained relationship.

There was a time when it was assumed that the vendor knew more about heat transfer than the purchaser. The burden of design and guarantee of performance was placed on the vendor . . . **times have changed.** The user has the opportunity to test heat exchangers at rated conditions and, occasionally, to retube or rebuild them in his own shops. The vendor is familiar with shop practices and possesses considerable "know-how" as far as mechanical details are concerned but he usually has to rely on a sparse amount of "*feedback*" of performance data with which he can check his design procedures. The theoretical data on heat transfer is available to user and vendor on an equal basis. The vendors have fairly-well publicized their knowledge of mechanical design in house organs or in the well-known editions of the *Standards of The Tubular Manufacturers Association*, known as **TEMA.** It is common knowledge that the purchaser or operator of the refinery and chemical plants for which heat exchangers are used does not have comprehensive physical property data or fouling data on the chemicals he produces. It is thus necessary for someone to estimate physical properties and fouling factors before a suitable heat exchanger may be rated. This should be done by the purchaser rather than by the vendor. The time is at hand when it is advantageous for both the purchaser and the vendor to pool their resources in the interests of a standard procedure for the procurement of heat exchangers.

It is impractical for each individual engineer who needs to specify an exchanger to send out his own inquiry. Therefore, it is common procedure for both the purchaser and vendor to establish lines of communication. For example, within the purchaser's company preliminary negotiations may be carried on between the **project engineers** and a **negotiating group.** This group organizes the specifications in a systematic fashion and transmits them to the sales engineer of the vendor company who, in turn, passes them on to the vendor's rating group. The rating is made, sent to the estimating department, and priced. The inquiry then becomes a quotation, and it goes back to the vendor's sales department and then back to the purchaser's negotiation depart-

HEAT EXCHANGER INQUIRY DATA SHEET

1.	Supplier's Job and Reference No.				
2.	Customer				
3.	Address				
4.	Plant Location				
5.	Service of Heat Exchanger				
6.					
7.					
8.	PERFORMANCE OF ONE UNIT				
9.		Shell Side		Tube Side	
10.	Fluid Circulated				
11.	Total Fluid Entering	lb/hr			
12.	Vapor	lb/hr			
13.	Liquid	lb/hr			
14.	Steam	lb/hr			
15.	Non-Condensables	lb/hr			
16.	Fluid Vaporized or Condensed	lb/hr			
17.	Steam Condensed	lb/hr			
18.	Gravity - Liquid (L) Vapor (V)	centipoises			
19.	Viscosity - Liquid (L) Vapor (V)				
20.	Molecular Weight - Vapors (V) Liquid (L)				
21.	Specific Heat - Liquids (L) Vapor (V)	Btu/lb/°F		Btu/lb/°F	
21A.	Thermal Conductivity	Btu/Hr Ft °F			
22.	Latent Heat - Vapors	Btu/lb		Btu/lb	
23.	Temperature In	°F		°F	
24.	Temperature Out	°F		°F	
25.	Operating Pressure	lb/sq in.		lb/sq in.	
26.					
27.					
28.	Pressure Drop - Max. Allowable				
29.	Fouling Resistance				
30.					
31.	Heat Exchanged - Btu/hr				
32.					
33.	CONSTRUCTION				
34.	Design Pressure	lb/sq in.		lb/sq in.	
35.	Test Pressure	lb/sq in.		lb/sq in.	
36.	Design Temperature	°F		°F	
37.	Tubes Min. O.D. BWG	Max. Length			
38.	Shell				
39.	Shell Cover	Floating Head Cover			
40.	Channel or Bonnet	Channel Cover			
41.	Tube Sheets-Stationary	Floating			
42.	Baffles - Cross				
43.	Baffle - Long				
44.	Tube Supports	Thickness			
45.	Gaskets				
46.	Connections - Shell - In Out	Series			
47.	Channel - In Out	Series			
48.	Corrosion Allowance - Shell Side	Tube Side			
49.	Code Requirements	Tema Class			
50.	Weights - Each Shell Bundle	Full of Water			
51.	Stress Relieving or X-Ray Requirements				
52.	Remarks: Inspection Procedure				

FIG. 1. Typical exchanger specification sheet.

ment to be compared with other quotations. Although this procedure does not seem to involve too much paper work or too many people, there are times when it would be advantageous for the **rating engineer** to talk or correspond directly with the **project engineer.**

Under this simple procedure, one would suspect that the quotations received from say five different vendors would be fairly uniform as to mechanical design and price. Usually this is not true. The reason is that the rating engineer is rarely given enough information. He has to estimate at least some of the physical properties; he has to guess as to what size tubes (diameter and length) will be acceptable to the purchaser; he has to select a type of exchanger (fixed tubesheet, floating tubesheet, U-bend); and finally he may need to make a choice as to installed position. There are other variables and usually so many that the user receives five quotations widely divergent in both surface area and price.

The solution to this problem is simple but it requires a little more work on the part of the purchaser's project engineer. The exchanger specification sheet, such as that shown in Fig. 1 and similar to that proposed by the Fourth Edition of Standards of Tubular Exchanger Manufacturers Association, is a useful form for inquiry specifications. The purchaser should fill-in as many spaces as possible, **especially those for physical properties and fouling resistance.** This TEMA form does not include thermal conductivity. This should be added because this is an important physical property for all types of heat transfer. Note that it is not necessary to name the fluid being heated or cooled if all the physical properties are given. The purchaser would not fill-in lines 1, 6, 7, 26, and 27. In lines 34 to 52 the user would indicate desired materials of construction, nozzle sizes, minimum (or preferred) tube diameter, maximum tube length, and corrosion allowance.

If an inquiry sheet similar to this one is filled-in, then each supplier will be quoting on exactly the same conditions, and there is a much greater chance that all quotations will be close in all respects. There are several user companies that rate their own exchangers and their inquiry sheets indicate mechanical construction details only. Normally, inquiries of this type are sent to heat exchanger manufacturers rather than to job-shops because the heat exchanger company is better qualified to produce a high-quality product.

After the quotations have been reviewed and the contract awarded, the purchasing departments of the user and vendor companies then cooperate and communicate to see that drawings are approved, material ordered, work scheduled, and delivery made. In each company, there will be activity in the areas of drafting, expediting, and inspection. The time which elapses between inquiry and delivery is often appallingly excessive. The only way to reduce this time interval is for the user and vendor to establish better lines of communication, and for each to supply to each other as much information as possible.

Today, there are available a host of special types of heat exchangers which, for some duties, are more adaptable and more economical than the usual shell-and-tube type. Many user companies are not familiar with the advantages of these special units because their specifications are too restrictive, their inquiries are sent only to shell-and-tube suppliers, and their purchasing departments prevent vendor representatives from talking directly with **project engineers.** Regardless of the well-written and widely published advertisements of these special exchangers, it must be conceded that the manufacturer is in the best position to decide on the applicability of his device for any particular job; so it is necessary that the purchaser send him inquiries and permit oral communications **between engineers** in both companies.

Suggestions have been made regarding the procedure for procurement of heat exchangers. Courteous communications between purchaser and vendor are in order. Purchasers are prone to tell the vendor when a single unit does not perform, but rarely do they tell the vendor of the many units that do perform. The vendor would appreciate receiving actual test data, and the user would certainly not be revealing any secrets in releasing this information.

Simple specifications should be strived for. All specifications are subject to interpretation, and the purchaser should try to explain to the vendor the reasons behind the specifications so that there will be a mutual understanding.

Deal with shops specializing in heat exchangers rather than with job shops. **Don't buy on price alone.** It is hard for the engineer to sell his own purchasing department on the fact that sometimes the higher quality, higher priced exchanger is the more economical but there are many times when the low-priced exchanger falls short on performance.

Be ethical in negotiation. If a vendor makes a suggestion which leads to a more economical design, it is unethical to pass this information along to all the other vendors. It is also unethical for the purchaser to reveal, to vendors, the prices obtained in the hope that all will reduce their prices. In the long run the business will be equally distributed because of the law of averages. However, when the business has been placed, it would seem to be courteous for the purchaser to so advise all vendors so that they may close their files and make room for additional inquiries.

It may appear to be inconsistent for a user to imply that, the purchaser, rather than the vendor, is responsible for most deficiencies in heat exchanger procurement procedures. But this has been done advisedly. It must be agreed that vendors have publicized their design methods, have (willingly) permitted purchaser representatives to witness and inspect fabrication in their shops, and have constantly offered their services and suggestions in heat transfer problems. Users have supplied only a small amount of test, operating, and maintenance data in return. *We suggest that heat exchanger procurement conditions can be improved if there is a more comprehensive interchange of information between user and vendor.* ★ ★ ★

How to design a multiple

Here is a new method suited to either hand or machine computation that you will want to add to your engineering files.

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Partial condensation of a mixture of vapors by cooling is among the most common refinery heat transfer operations. Stripper overhead condensers, stabilizer condensers, etc. involve multiple components which are distributed in some manner between both condensate and vapor streams. There have been a number of articles devoted to development of practical and theoretical partial condenser design procedures. However, because heat and mass transfer must be treated simultaneously, these methods are so complicated that they are necessarily limited to mixtures involving only one or two condensible components. In this article the relationships provided do not involve the usual trial and error mass and heat transfer calculations.

DESIGN OF HEAT EXCHANGER EQUIPMENT to cool a vapor stream and simultaneously condense a portion of that stream is complicated by several unusual conditions of heat transfer.

First, the unit is both a cooler and a condenser, and unless it approaches very closely to one or the other of these conditions it cannot be designed as either one.*[1-9]

Second, the mass flow rate of the vapor stream and the physical properties of both streams can vary appreciably over the length of the exchanger.

Third, as pointed out by Bras,[3] without interaction of the vapor and liquid phases involved, the rate of mass transfer can be such as to allow the vapor phase to become either superheated or, in the case of a heavy, low diffusity material, to cause condensation in the vapor phase immediately surrounding the tube (fog formation).

In the method presented here it is assumed that:

1. The mixture to be cooled and partially condensed has a range in molecular weight sufficiently small as to cause rapid diffusion through the inert gaseous film so that fog forming conditions are not reached.
2. There is sufficient interaction of the vapor and liquid phases, by such means as liquid splashing off the tubes and baffles, for an equilibrium condition to exist between the two phases.

Heat transfer occurring in the cooler-condenser can be viewed as being composed of two different parts; i.e., sensible heat transfer or energy transfer in which a temperature change occurs, and latent heat transfer or energy transfer in which a change of phase is involved. The rate of sensible heat transfer on the partial condensing side of the tubes is given by:

$$\frac{dQ_s}{dA} = h_o(t_v - t_c) \quad . \quad . \quad . \quad . \quad . \quad (1)$$

while the rate of latent heat transfer is given by:

$$\frac{dQ_L}{dA} = K_M\lambda(p_v - p_c) \quad . \quad . \quad . \quad . \quad (2)$$

*The heat transfer effects of even small quantities of non-condensibles in a total condenser can be appreciable as pointed out by McAdams.[10]

component partial condenser

What is required, however, is an effective outside coefficient which, when multiplied by the difference between the bulk vapor and condensate interface temperatures, would yield the total heat flux, or:

$$h_{eff}(t_v - t_c) = \frac{dQ_T}{dA} \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Dividing equation (3) by equation (1) yields

$$\frac{h_{eff}}{h_o} = \frac{dQ_T}{dQ_s} \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

The partial condensing effective heat transfer coefficient defined can now be related to the amount of flowing fluid

Table 1. Outline of Design Procedure.

Step 1. From the inlet vapor composition and pressure calculate the vapor and liquid compositions at the inlet, outlet, and at various intermediate temperatures.

Step 2. Plot the mass rate of vapor flow versus temperature and determine the slope at various points as illustrated in Fig. 1.

Step 3. From the slopes determined in Step 2, and the vapor flow rates and physical properties of the vapor and liquid streams determine values for Q_T and

$$\left[1 + \frac{\lambda}{Wc_p}\left(\frac{dW}{dt_v}\right)\right] \text{ or } \frac{h_{eff}}{h_o}$$

Step 4. Lay out a proposed exchanger and from the geometry, physical properties of the fluids and flow rates determine tube wall, fouling, condensing and cooling medium resistances and h_o and t_w* as a function of t_v.

Calculate U_o as a function of t_v and plot $1/U_o$ $(t_v - t_w)$ versus Q_T and graphically integrate the area under the curve being the required heat transfer area. Compare the required versus the provided heat transfer area and if necessary, repeat Steps 4 and 5.

*t_w must frequently be calculated using an idealized flow pattern such as co- or countercurrent and possibly later making a trial-and-error calculation based on the actual flow.

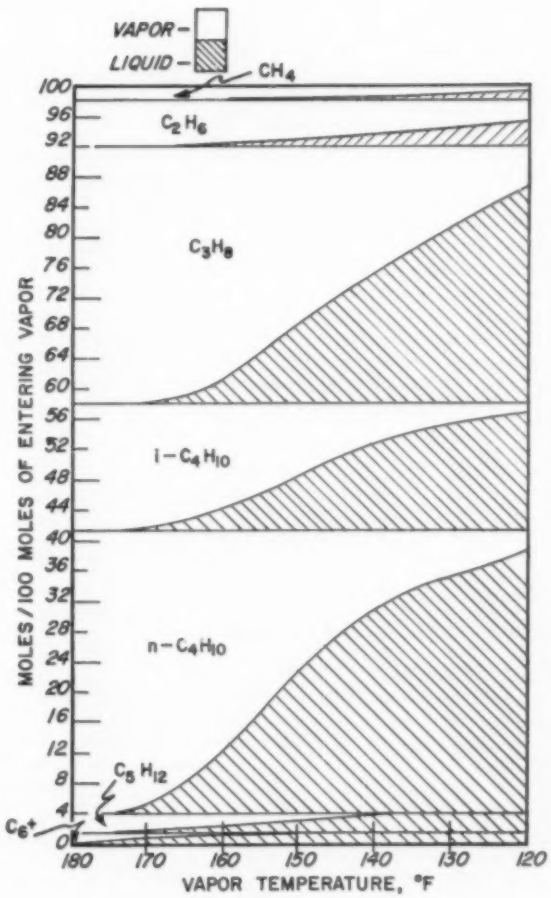

FIG. 1. Summary of condensing path by components

by noting that the rate of sensible heat transfer can also be expressed as:

$$dQ_s = Wc_p dt_v \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)^*$$

While the rate of latent energy removal is given by:

$$dQ_L = \lambda dW \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

so that, neglecting the liquid cooling:

$$dQ_T = Wc_p dt_v + \lambda dW \quad . \quad . \quad . \quad . \quad (7)$$

Substituting equations (5) and (7) into equation (4) results in:

$$h_{eff} = h_o \left[\frac{Wc_p dt_v + \lambda dW}{Wc_p dt_v} \right] = h_o \left[1 + \frac{\lambda}{Wc_p} \left(\frac{dW}{dt_v} \right) \right] \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

For a unit condensing material on the shell side of the exchanger the overall coefficient is then:

$$\frac{1}{U_o} = \frac{1}{h_{eff}} + \frac{1}{h_{cond}} + r_o + \frac{XA_o}{k_m A_M} + \frac{A_o}{A_i} r_i + \frac{A_o}{A_i h_i} \quad . \quad . \quad . \quad . \quad . \quad (9)$$

A similar relationship, of course, holds for condensing inside the tubes. For condensing outside of finned tubes a fin resistance, r_f, must be added.[11]

Equations (8) and (9) are now in a form to be used for the heat transfer design of a cooler-condenser. As is pointed out in the design example given below, these relationships describe point coefficients. Thus it is necessary to know their variation over the length of the exchanger. As is illustrated later, however, using the assumption of phase equilibrium previously described, the ratio of h_{eff}/h_o is independent of the exchanger geometry and depends solely on the physical properties of the vapor and liquid over the temperature range involved. A general procedure which can be used to determine the heat transfer area requirements is given in Table 1.

Design example

Part I — Steps 1, 2 and 3 of Table 1.

A. Statement of Problem

A mixture having the composition indicated in Table 2 is to be cooled and partially condensed from 180 to 130 F at 150 psig at the rate of 50,000 lb per hr in a shell and tube exchanger against treated cooling tower water available at 80 F. Determine the size and layout of an exchanger to perform this task.

B. Preliminary Calculations

In order to size the exchanger requested, it is advantageous to make some preliminary calculations before attacking the heat transfer portion as indicated in Table 1. For these calculations it is simpler to work with smaller numbers than the total flow provides, consequently a basis of 100 moles of entering vapor will be used throughout this section unless otherwise stated.

*Actually the full differential includes the term (c_p) (t) dw which is related to the rate of mass transfer and is handled separately.

Table 2. Summary of Heat Exchanger Inlet Conditions.

	Component	Mole %
Composition	CH_4	1.79
	C_2H_6	5.20
	C_3H_8	34.20
	iC_4H_{10}	16.65
	nC_4H_{10}	38.20
	C_5H_{12}	2.33
	$C_6H_{14}+$	1.63*
		100.00
Temperature	180F	
Pressure	165 psia	

*Assumed throughout to have the properties of *n*-heptane.

Table 3. Example Equilibrium Calculations at 160 F.

Assume V/L = 5.0

Component	Moles M	K**	$K\left(\frac{V}{L}\right)+1$	$L = \frac{M}{K(V/L)+1}$
CH_4	1.79	18.8	95	0.02†
C_2H_6	5.20	5.2	27	0.19†
C_3H_8	34.20	1.91	10.55	3.23
iC_4H_{10}	16.65	0.96	5.8	2.87
nC_4H_{10}	38.20	0.74	4.7	8.13
C_5H_{12}	2.33	0.30	2.5	0.93
$(C_6+)^*$	1.63	0.052	1.26	1.29
	100.00			L=16.66

V = 100 − 16.66 = 83.34
Actual V/L = 83.34/16.66 = 5.00

*Assumed throughout to have the properties of C_7H_{16}.
**Obtained from 1957 NGSMA[12] at convergence pressure of 3000 psia.
†Approximate value.

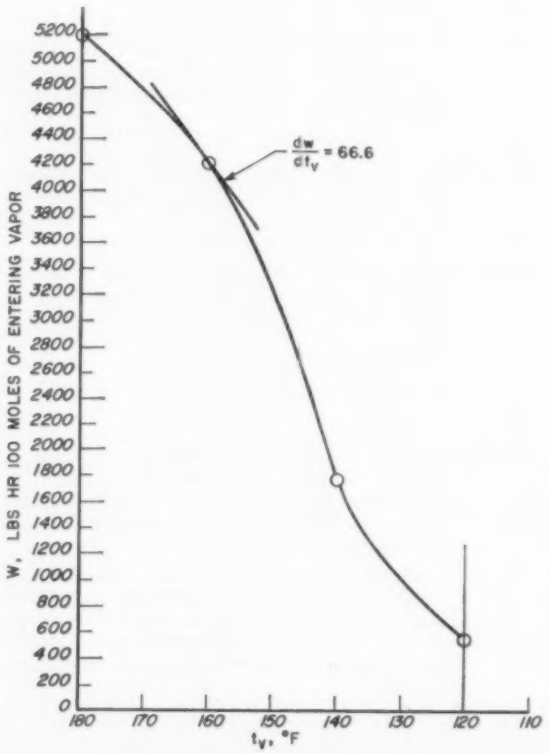

FIG. 2. Summary of overall condensing path.

(a) Step 1. As a first step the vapor-liquid equilibrium or condensing curve will be determined at several temperatures. From a calculation at the inlet conditions (180 F, 165 psia) it was determined that the vapor enters the exchanger at approximately the dew point of the mixture. Next the composition and quantities of vapor and liquid are determined at 160, 140 and 120 F by using the equilibrium constants[12] of the components at each condition. The calculation for 160 F is illustrated in Table 3. The outlet conditions for the exchanger will be obtained by interpolation. A summary of these calculated results is given in Table 4 and Fig. 1 where the calculated molar condensing path is illustrated.

(b) Step 2. Using the results summarized in Table 4 and the molecular weight of each component, the pounds per hour of flowing vapor can be calculated at each temperature selected. This result is plotted in Fig. 2 where a smooth curve has been drawn through the calculated points. The slope of this curve at each of the points yields the value of dW/dt_v required in the determination of h_{eff}/h_o.

(c) Step 3. The values of dW/dt_v obtained from Fig. 2 and the value of λ/c_p obtained from the *NGSMA Engineering Data Book*[12] and Fig. 3, combined with the values of W calculated above, allow the calculation of h_{eff}/h_o as indicated in Table 5. Once these values of h_{eff}/h_o are obtained we are ready to proceed with the design of the exchanger, Steps 4 and 5 of Table 2.

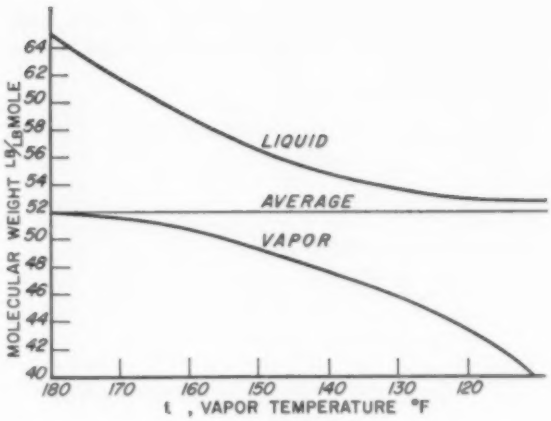

FIG. 3. Variation of average molecular weights with temperature.

Water rate. Using a maximum outlet water temperature of 110° F, the required water rate is:

$$W_w = \frac{6{,}110{,}000}{30} = 203{,}700 \text{ lb/hr}$$

or:

$$W_w = \frac{203{,}700}{62} = 3280 \text{ cu ft/hr}$$

Part II — Steps 4 and 5 of Table 1.

C. Heat Duty and Water Rate Calculations

Step 4. The total heat duty can be calculated from the difference in energy contents of the inlet and exit streams. From Reference 12 these values are obtained as:

$$\Delta H_v = 326 - 316 = 10 \text{ Btu/lb}$$

and

$$\Delta H_L = 326 - 177 = 149 \text{ Btu/lb}$$

and from Table 5 at the exchanger outlet (per 100 moles or 5200 lb of feed):

$$W = 1000 \text{ lb}$$

$$W_L = 4200 \text{ lb}$$

so that:

$Q = (149)(4200) + (10)(1000) = 636{,}000$ Btu/100 moles or for 50,000 lb/hr:

$$Q_T = 636{,}000 \left(\frac{50{,}000}{5200}\right) = 6{,}110{,}000 \text{ Btu/hr}$$

In a similar manner, intermediate heat duties are calculated and summarized in Table 6.

D. Assumed Heat Exchanger Arrangement

Assume a 23-in. exchanger containing 324 tubes having the properties listed below on a 1-in., 45° square pitch with a single pass shell side and double pass tube side. The shell

Table 5. Determination of h_{eff}/h_o.

Temperature, F	$\frac{dw}{dt_v}$	W	$\frac{1}{W}\frac{dw}{dt_v}$	$\frac{\lambda}{c_p}$	$\left(\frac{\lambda}{c_p}\right)\left[1+\frac{\lambda dW}{W c_p dt_v}\right]=\frac{h_{eff}}{h_o}$
180	33.3	5200	0.0064	287	2.77
170	57.1	4690	0.0122	293	4.58
160	66.6	4218	0.0158	295	5.63
150	107.1	3250	0.033	298	10.85
140	158.3	1769	0.0895	309	28.7
130	54.8	1000	0.0548	316	18.3

Table 6. Intermediate Heat Duties and Water Temperatures.*

Vapor Temperature, F	Q_T x 10-6**	t_w, F
180	0	110
170	0.72	106.5
160	1.48	102.7
150	2.81	96.2
140	4.89	86.0
130	6.11	80.0

*Assuming countercurrent operations.
**Heat transferred from the inlet condition to the condition at the vapor temperature indicated.

Table 4. Summary of Calculated Condensing Path.

Temp. F	CH_4 G	CH_4 L	C_2H_6 G	C_2H_6 L	C_3H_8 G	C_3H_8 L	iC_4H_{10} G	iC_4H_{10} L	nC_4H_{10} G	nC_4H_{10} L	C_5H_{12} G	C_5H_{12} L	C_6H_{14}+ G	C_6H_{14}+ L	ΣG	ΣL
180	1.79	—	5.2	—	34.2	—	16.65	—	38.2	—	2.33	—	1.63	—	100	—
160	1.77	0.02	5.01	0.19	30.97	3.23	13.78	2.87	30.07	8.13	1.40	0.933	0.33	1.295	83.33	16.67
140	1.64	0.15	3.82	1.38	16.80	17.40	4.75	11.90	10.1	28.10	0.29	2.04	0.04	1.59	37.44	62.56
120	1.30	0.49	1.95	3.25	5.80	28.40	1.35	15.30	2.60	35.60	0.06	2.27	0.01	1.62	13.07	86.93

side is to have baffles spaced every 18 in. with 35% baffle cuts on the diameter. The required length of the tubes is to be determined.

Tube specifications:

$$\frac{3}{4} \text{ in.} = 14 \text{ BWG Admiralty Tube}$$

$$OD = 0.750 \text{ in.}$$

$$ID = 0.584 \text{ in.}$$

$$\text{Wall Thickness} = 0.083 \text{ in.}$$

$$A_o = 0.1963 \text{ sq ft/ft}$$

$$A_i = 0.153 \text{ sq ft/ft}$$

$$A_o/A_i = 1.285$$

$$A_{cs} = \frac{\pi(0.584)^2}{576} = 0.00186 \text{ sq ft/tube}$$

E. Determination of Flow Areas and Velocities

(a) Water flow area and velocity.

The tube side flow area is:

$$A_W = (324/2)(0.001418) = 0.23 \text{ sq ft}$$

for a tube-side water velocity of:

$$V_i = \frac{3280}{(3600)(0.23)} = 3.96 \text{ ft/sec}$$

which is acceptable.

(b) Shell side flow areas.

Number of tubes on exchanger centerline =

$$\left(\frac{\text{shell diameter}}{\text{pitch}\sqrt{2}}\right) - 1 = \frac{23}{1.414} - 1 = 15$$

Number of tubes in flow path = 2(15) − 1 = 29 (on zig-zag path)

Number of spaces for flow = 28 + ends = 30

$$\text{Cross flow face area} = \left(\frac{30}{12}\right)\left(\frac{18}{12}\right) = 3.75 \text{ sq ft}$$

$$\text{Projected metal area} = (D_o)(L)(\text{number of tubes}) = \left(\frac{0.75}{12}\right)\left(\frac{18}{12}\right)(29) = 2.72 \text{ sq ft}$$

for a free cross flow area of:

$$3.75 - 2.72 = 1.03 \text{ sq ft}$$

$$\text{Total cross sectional area of shell} = \frac{\pi(23)^2}{576} = 2.89 \text{ sq ft}$$

$$\text{Window area}^{13} = (0.245)\left(\frac{23}{12}\right)^2 = 0.90 \text{ sq ft}$$

$$\text{Number of tubes in window area} = \left(\frac{0.90}{2.89}\right)(324) = 101 \text{ tubes}$$

$$\text{Free flow area in baffle window} = 0.90 - \left[\frac{(0.75)^2\pi}{576}\right] = 0.90 - 0.31 = 0.59 \text{ sq ft}$$

$$\text{Geometric mean area} = A_{GM} = \sqrt{(0.59)(1.03)} = 0.78 \text{ sq ft}$$

F. Determination of Heat Transfer Resistances

The overall heat transfer coefficient is related to the individual resistances by the relationship:

$$\frac{1}{U_o} = \frac{1}{h_{eff}} + \frac{1}{h_{cond}} + r_o + r_m + \frac{A_o}{A_i} r_i + \frac{A_o}{A_i h_i}$$

All of the resistances given above are relatively constant except possibly the first two, $1/h_{eff}$ and $1/h_{cond}$, which can vary appreciably throughout the exchanger. The remaining resistances are first determined as:

(a) Fouling resistances.

$$\text{Assume outside fouling, } r_o = 0.0005$$

$$\text{Assume inside fouling, } r_i = 0.001$$

$$\frac{A_o}{A_i} r_i = 0.00128 \frac{\text{hr} - \text{deg F} - \text{sq ft (outside)}}{\text{Btu}}$$

(b) Metal resistance.

$$r_m = \frac{XA_o}{k_m A_M} = \frac{(0.083)(0.196)}{(12)(64)(0.174)} = 0.00012 \frac{\text{hr} - \text{deg F} - \text{sq ft (outside)}}{\text{Btu}}$$

(c) Water film resistance.[10]

$$h_i = 150\,(1 + 0.011\,t_w)\frac{V_i^{0.8}}{d_i^{0.2}}$$

where:

V_i = water velocity, ft/sec

d_i = inside diameter of tube, in.

t_w = average water temperature, F

$$h_i = \frac{150\,(2.05)(3)}{0.896} = 1030$$

or

$$\frac{A_o}{A_i h_i} = \frac{1.285}{1030} = 0.00125 \frac{\text{hr} - \text{deg F} - \text{sq ft (outside)}}{\text{Btu}}$$

The effective and condensing coefficients are now determined in the following manner:

(d) Determination of h_{eff}.

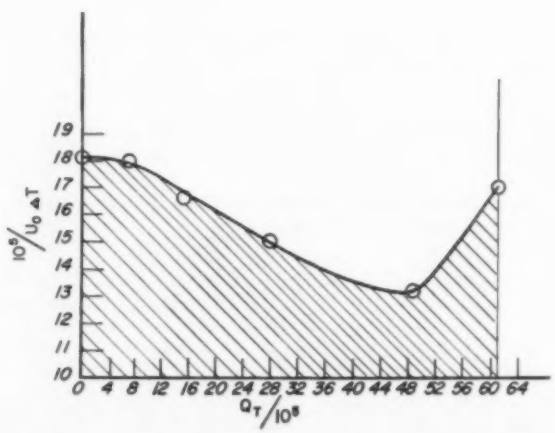

FIG. 4. Graphical integration to determine required heat transfer area.

In order to determine the effective outside coefficient it is necessary to first determine the gas film coefficient for various vapor temperatures. This can be accomplished in the following manner.

The gas film coefficient is related to the mass flow rate and physical properties of the vapor by[14]:

$$\frac{h_o D_o}{k_v} = 0.22\left(\frac{D_o G}{\mu}\right)^{0.6}(Pr^{1/3})\left(\frac{\mu}{\mu_w}\right)^{0.14}$$

For the hydrocarbon mixture under consideration, the physical properties are very nearly constant so that the average values listed below can be used throughout the entire vapor temperature range.

$$\mu = 0.01 \text{ cp} = 0.0242 \text{ lb/ft} - \text{hr}$$

$$k_v = 0.012 \text{ Btu/hr} - \text{F} - \text{ft}$$

$$Pr^{1/3} = 1.05$$

Assuming $(\mu/\mu_w)^{0.14} = 1$, the outside coefficient is then related to the vapor flow rate by:

$$h_o = 0.0655\, G^{0.6}$$

at the inlet of the exchanger the mass flow rate is:

$$G = \frac{W}{A_{GM}} = \frac{50{,}000}{0.78} = 64{,}100 \text{ lb/sq ft} - \text{hr}$$

and

$$G^{0.6} = 766$$

Therefore, $h_o = 50.2$

and from Table 5, $h_{eff}/h_o = 2.77$

Therefore, $(h_{eff})_{inlet} = (50.2)(2.77) = 139$

In the same manner, the gas film and effective outside coefficients are evaluated for the other temperatures selected. These values are listed in Table 7.

(e) Determination of the condensing coefficient.
The condensing film coefficient is evaluated from the relationship[15]:

$$h_{cond} = 0.725\left[\frac{k_f^3 \rho_f^2 g_c}{\mu_f}\right]^{1/4}(\lambda)^{1/4}\left(\frac{1}{D_o}\right)^{1/4}\left(\frac{1}{\Delta t_c}\right)^{1/4}$$

Assuming an average mixture for condensing, the physical property group can be assumed to have a constant value over the entire condensing range of[15]:

$$\left[\frac{k_f^3 \rho_f^2 g_c}{\mu_f}\right]^{1/4} = 171$$

while:

$$\lambda^{1/4} = (125)^{1/4} = 3.25$$

and

$$\left(\frac{1}{D_o}\right)^{1/4} = \left(\frac{12}{0.75}\right)^{1/4} = 2$$

substituting,

$$h_{cond} = (0.725)(171)(3.25)(2)(1/\Delta t_c)^{1/4} = 805\,(1/\Delta t_c)^{1/4}$$

MEET THE AUTHOR

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The determination of the temperature drop across the condensate film involves a trial-and-error procedure which can be accomplished in the following manner:
assume

$$h_{cond} = 424 \text{ at } t_v = 180 \text{ F}$$

then

$$\frac{1}{U_o} = \frac{1}{139} + \frac{1}{424}$$

$$+ 0.0005 + 0.00012 + 0.00128 + 0.00147 = 0.01271$$

and

$$U_o = 1/0.01271 = 78.5$$

$$\Delta t_c = \frac{U_o}{h_{cond}}(\Delta T)$$

at the inlet of the exchanger, assuming countercurrent flow:

$$\Delta T = 180 - 110 = 70 \text{ F}$$

substituting

$$\Delta t_c = \frac{78.5}{424}(70) = 13 \text{ F}$$

$$\left(\frac{1}{\Delta t_c}\right)^{1/4} = \frac{1}{1.895}$$

or

$$h_{cond} = 805/1.895 = 424.$$

which checks exactly with the assumed value.

Using the above procedure, the condensing coefficient was evaluated at each of the vapor temperatures selected. These values are listed in Table 7.

Table 7. Summary of Point Coefficients.

tv, F	ho (gas film)	heff	hcond	Uo	ΔT	UoΔT	10^5/UoΔT
180	50.2	139	424	78.5	70.0	5500	18.2
170	47.0	215	409	87.5	63.5	5550	18.0
160	44.4	250	412	104.3	57.3	5980	16.7
150	37.8	410	399	123.5	53.8	6650	15.0
140	26.3	730	380	140.0	54.0	7550	13.2
130	18.7	342	415	118.0	50.0	5900	17.0

G. Determination of the Required Heat Transfer Area

Step 5. The overall coefficient at each selected vapor temperature was evaluated in the manner described above. The corresponding temperature difference driving force, ΔT, was evaluated by assuming countercurrent operation of the condensing vapor and the cooling water, and calculating the water temperature at each of the selected vapor temperatures, using a heat balance between the water and vapor streams. The overall coefficient and temperature difference values are listed in Table 7.

The required heat transfer area is determined by a graphical integration of the relationship:

$$A = \int_{o}^{Q_T} \left(\frac{1}{U_o \Delta T}\right) dQ_T$$

The required area for this example is determined from a graphical integration of $10^5/U_o\Delta T$ versus $Q_T/10^5$ as indicated in Fig. 4. From the graphical integration indicated in this figure, the required area is 943 sq ft.

The required length of the tubes is:

$$L_t = \frac{943}{(324)(0.1963)} = 14.8 \text{ ft}$$

Using an exchanger 16 ft long, the area provided is

$$(324)(0.1963)(16) = 1020 \text{ sq ft}$$

for an excess area of

$$\frac{1020 - 943}{943} \times 100 = 8.2\%$$

which is considered satisfactory.

Nomenclature

A = Heat transfer area, defined by the coefficient with which it is associated, sq ft.
A_{cs} = Tube inside flow area, sq ft/tube.
A_{GM} = Geometric mean flow area, sq ft.
A_i = Tube inside area, sq ft.
A_M = Tube metal log-mean area, sq ft.
A_o = Tube outside heat area, sq ft.
c_p = Vapor heat capacity, Btu/lb – F.
d_i = Inside tube diameter, in.
D_i = Inside tube diameter, ft.
D_o = Outside tube diameter, ft.
G = Vapor mass flow rate, lb/hr – sq ft.
h_{cond} = Condensing coefficient, Btu/hr – F – sq ft.
h_{eff} = Effective coefficient for partial condensing, Btu/hr – F – sq ft.
h_o = Gas film coefficient, Btu/hr – F – sq ft.
ΔH_v = Enthalpy difference of entering and exit vapor streams, Btu/lb.
ΔH_L = Enthalpy difference between entering vapor and exit liquid streams, Btu/lb.
K = Vapor-liquid equilibrium constant, dimensionless
k_v = Gas thermal conductivity, Btu/hr – F – sq ft.
k_m = Metal thermal conductivity, Btu/hr – f – sq ft.
k_c = Mass transfer coefficient, lb/hr – sq ft – psi.
$\left[\frac{k_f^3 \rho_f^2 g_c}{\mu_f}\right]^{1/4}$ = Nusselt condensing physical property group, lb – ft – F/Btu.
L = Moles of liquid.
L_t = Tube length, ft.
P_c = Vapor pressure of condensing material at t_c, psia.
P_v = Partial pressure of condensing material, psia.
Pr = Prandtl Number, $\left(\frac{c_p \mu}{k_v}\right)^{1/3}$, dimensionless
Q = Heat transfer rate, Btu/hr.
Q_L = Rate of latent heat transfer, Btu/hr.
Q_s = Rate of sensible heat transfer, Btu/hr.
Q_T = Total heat transfer rate, Btu/hr.
r_i = Tube inside fouling factor, hr – F – sq ft (inside area)/Btu.
r_o = Tube outside fouling factor, hr – F – sq ft (outside area)/Btu.
t_c = Vapor-condensate interface temperature, F.
Δt_c = Temperature drop across condensate film, F.
t_v = Flowing vapor temperature, F.
t_w = Cooling medium (water) temperature, F.
ΔT = Temperature difference driving force, $(t_v - t_w)$.
U_o = Overall heat transfer coefficient, Btu/hr.
V = Moles of vapor.
V_i = Inside water velocity, ft/sec.
W = Vapor mass flow rate, lb/hr.
W_L = Liquid mass flow rate, lb/hr.
W_W = Water flow rate, lb/hr.
X = Tube wall thickness, ft.
λ = Latent heat of vaporization, Btu/lb.
μ = Vapor viscosity, centipoise or lb/ft – hr.
μ_w = Vapor viscosity at condensate interface temperature, centipoise or lb/ft – hr.

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Design considerations for . . .

sectional heat exchangers

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ENGINEERS in a hydrocarbon process industry recently faced the problem of designing a high pressure gas cooler which could be economically installed, and located as close to the compressor as possible. This would enable the piping to be shop fabricated and shipped complete with the compressor for installation by the contractor.

This problem was solved by using fintube double pipe sections mounted directly over the compressor (Fig. 1). This gave an installation with substantial savings in high pressure piping costs. The sections are easily accessible for serving and inspection without the necessity of installing any special handling equipment. All connections to the heat exchangers are external and can be easily checked while the compressor is operating.

This is one example of the effective use of extended surface double pipe type heat transfer equipment. Use of this type of equipment has grown greatly during the last six years, partly because of the advantages of the fintube itself as a media of heat transfer and the mechanical design nature of the equipment.

The fintube

The fintube offers advantages in many applications. To get a clearer understanding of this tool, it is necessary to first go to the basics of heat transfer. The basic equation for the amount of heat transferred in an exchanger is given by

$$Q = U \times A \times LMTD \quad . \quad . \quad . \quad (1)$$

where

Q = Btu/hr
U = Overall heat transfer coefficient Btu/hr/sq ft/F
A = Surface – sq ft
LMTD = Log mean temperature difference of the bulk streams' temperatures

You can see that the amount of heat transferred is directly proportional to the surface. Therefore, if a bare tube can have its surface increased, then an extended surface tube should transfer more heat than the equivalent length of bare tube. This is advantageous because it allows a heat exchanger to be very compact for a given duty.

However, the extended surface cannot be pro-rated equally with bare tube surface. Should an exchanger require 300 sq ft of bare tube surface to transfer a given quantity of heat, you cannot say that it will also require 300 sq ft of extended surface also. The reason is the effectiveness of the fin, or the fin efficiency, has to be considered. Fin efficiency will govern the choice of a particular fintube for a specific application.

Sectional type heat exchangers em-

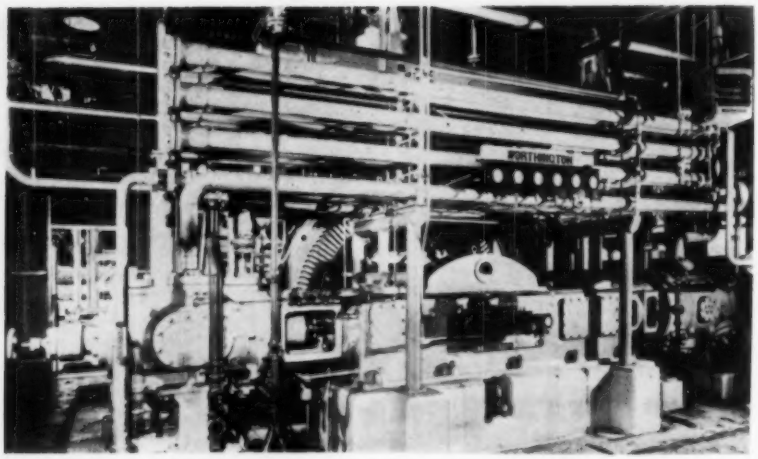


FIG. 1. Fintube double pipe sections mounted directly over compressor. The sections and connecting piping were shipped to the contractor along with the compressor as a package.

ploy longitudinal fins. The equation for the fin effectiveness is given by the equation

$$E = (\text{Tan } X)/X \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where

$X = L\,(h_f/6Kt)^{0.50}$

L = Fin height, in.

h_f = Fin film coefficient, Btu/hr/sq ft/F

K = Conductivity of fin material, Btu/hr ft²/F/ft

t = Fin thickness, in.

Fig. 2 is a graphic analysis of the effects these variables have on the fin effectiveness. The materials used are common for this type of equipment. The effect of fin height on the fin effectiveness is shown by comparing Curves 1 and 2. Curves 3 and 2 give

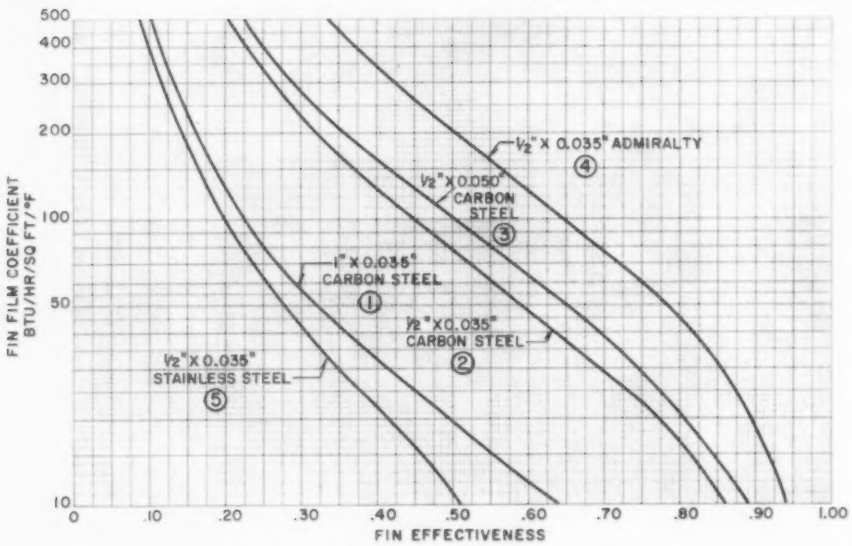


FIG. 2. Fin effectiveness vs fin film coefficient for various fin heights, fin thicknesses, and materials (longitudinal fins).

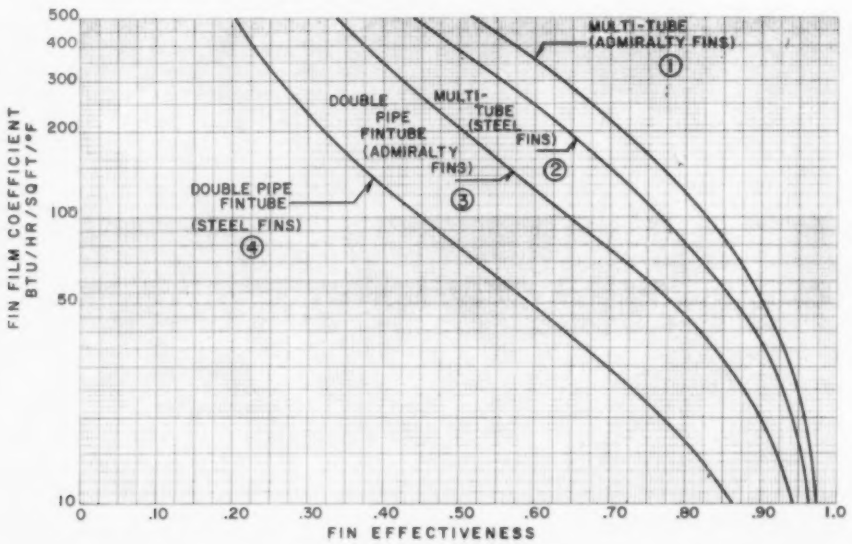


FIG. 3. Fin effectiveness of double pipe fintube (Styles I and II) vs multitube (admiralty fins).

the difference of fin thickness on the fin effectiveness. The difference the fin metal conductivity has on fin effectiveness can be seen by studying Curves 5, 2 and 4, which are in order of increasing fin metal conductivity, respectively.

Any one of these curves shows how the fin effectiveness varies with the heat transfer coefficient, h_f, on the fin side.

The overall heat transfer coefficient in any heat exchanger is based on the individual film coefficients obtainable from the two fluids exchanging heat. The optimum in design is such that the film coefficients for each fluid in an exchanger should be the maximum obtainable within limit of pressure drop and fouling imposed by specifications, and should approach the same magnitude. This is not always possible to do because of the heat transfer characteristics of the fluids exchanging heat. A typical example of this would be a water cooler using atmospheric air as the cooling fluid. It is practically impossible under average conditions to have a film coefficient on the air side approach that which is possible on the water side of this exchanger. Therefore, with such an application the total ability of a tube to transfer heat to the air can be increased considerably by adding fins to the outside of the tube and passing the air over these fins.

For purposes of explanation . . . let us assume an example where the coefficient possible on the air is 25 Btu/hr/sq ft/F, and the water in the tubes has a film coefficient of 1000 Btu/hr/sq ft/F. Further, let us assume that the tube wall is very thin and there is no fouling on either stream. The overall heat transfer coefficient based on the *inside tube wall surface* then is

$$U_i = \frac{25 \times 1000}{1000 + 25}$$
$$= 24.4 \text{ Btu/hr/sq ft/F}$$

Assuming the same conditions with the exception that fin surface is applied to the outside of the tube which increases the surface of the bare tube by a factor of 10 and this surface has a fin effectiveness of 0.75, the overall heat transfer coefficient based on the inside tube surface becomes

$$U_i = \frac{25 \times 10 \times .75 \times 1000}{1000 + (25 \times 10 \times .75)}$$
$$= 158 \text{ Btu/hr/sq ft/F}$$

This fintube overall heat transfer coefficient is considerably greater (a ratio of over 6/1) than the bare tube based on the same individual film coefficients.

Should the need arise for an exchanger which has a fluid on one side that by reason of pressure drop, fouling or fluid characteristics, will have a film coefficient lower than the film coefficient expected from the other stream, then fins should be thoroughly investigated.

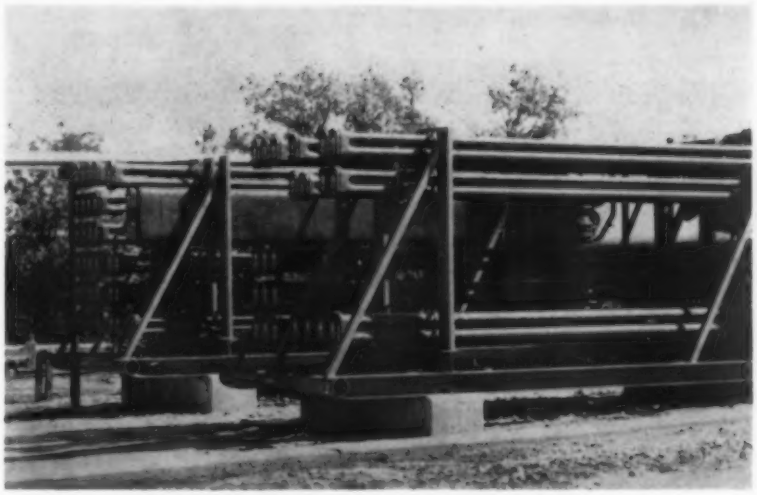


FIG. 4. A plant with four coolers, two condensers, one liquid exchanger, and one gas-to-liquid exchanger, all of which use the same basic sectional heat exchanger style.

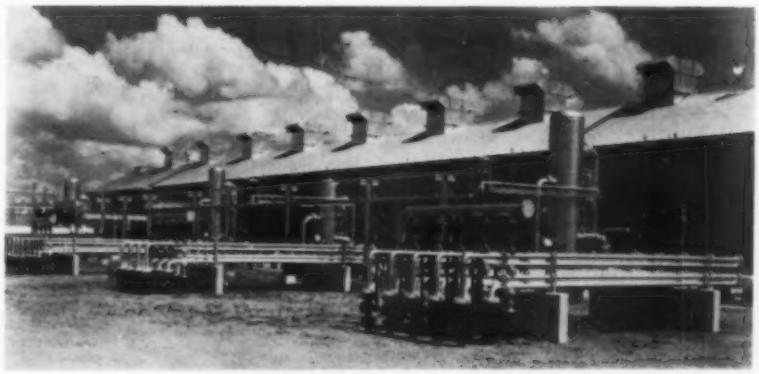


FIG. 5. Only one extra parallel stream of sectional exchangers are needed, rather than a complete standby unit.

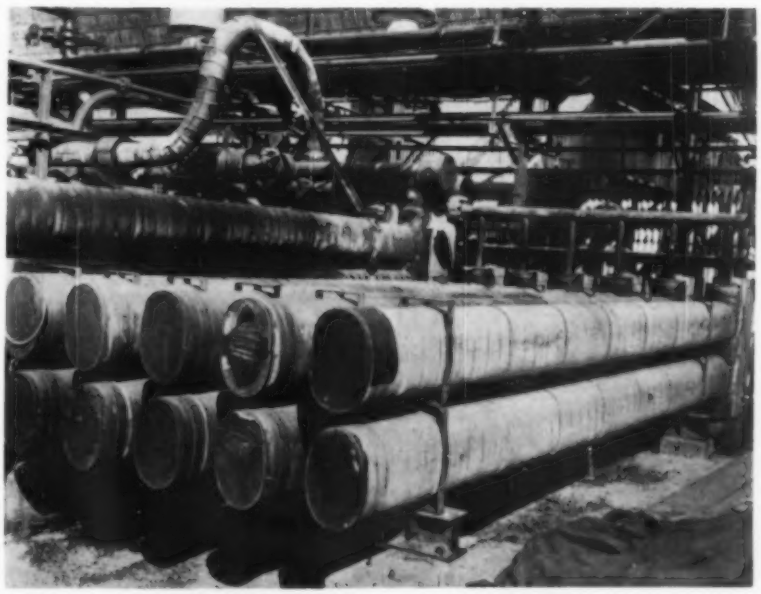


FIG. 6. A total of five sections will be stacked on top of these 10 to accommodate a 100% plant capacity condition.

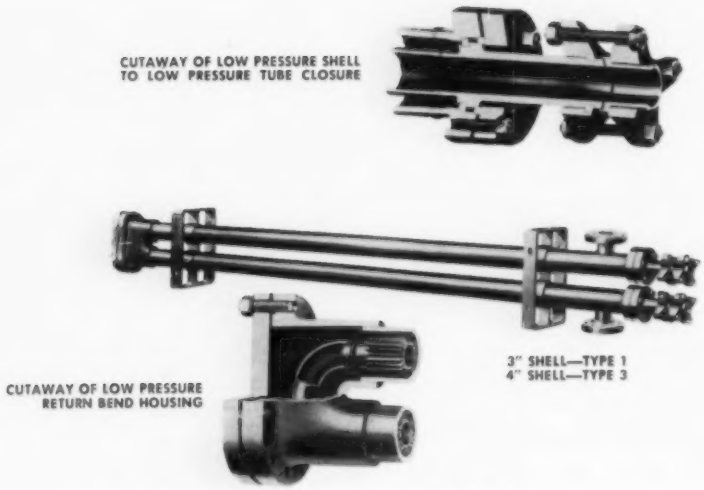

CUTAWAY OF LOW PRESSURE SHELL TO LOW PRESSURE TUBE CLOSURE
3" SHELL—TYPE 1
4" SHELL—TYPE 3
CUTAWAY OF LOW PRESSURE RETURN BEND HOUSING

FIG. 7. Double pipe fintube sections, Style I.

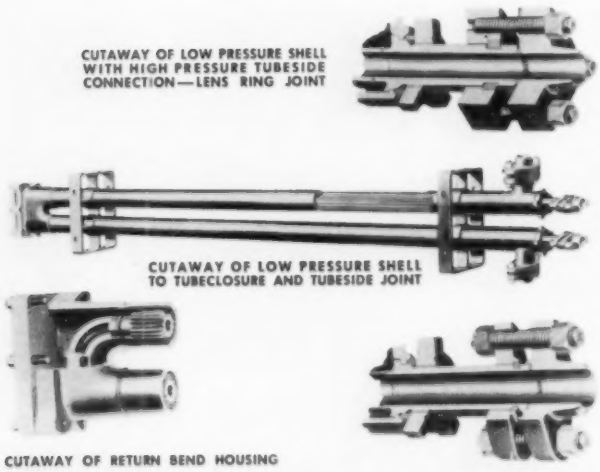

CUTAWAY OF LOW PRESSURE SHELL WITH HIGH PRESSURE TUBESIDE CONNECTION—LENS RING JOINT
CUTAWAY OF LOW PRESSURE SHELL TO TUBECLOSURE AND TUBESIDE JOINT
CUTAWAY OF RETURN BEND HOUSING

FIG. 8. Double pipe fintube sections, Style II.

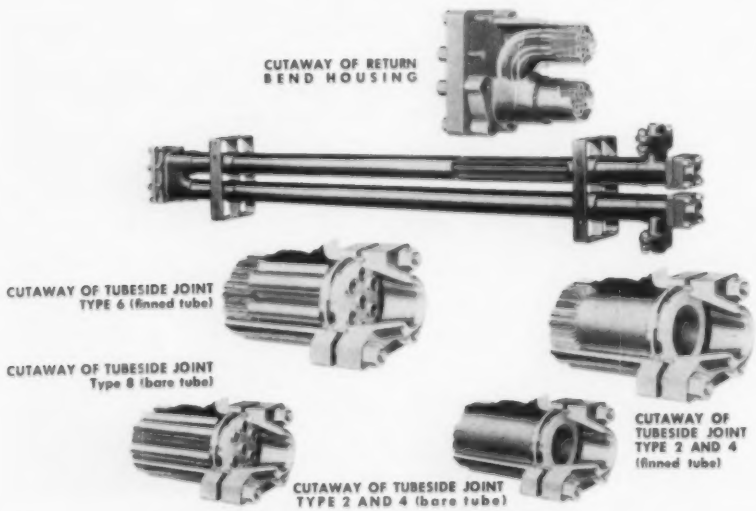

CUTAWAY OF RETURN BEND HOUSING
CUTAWAY OF TUBESIDE JOINT TYPE 6 (finned tube)
CUTAWAY OF TUBESIDE JOINT Type 8 (bare tube)
CUTAWAY OF TUBESIDE JOINT TYPE 2 AND 4 (finned tube)
CUTAWAY OF TUBESIDE JOINT TYPE 2 AND 4 (bare tube)

FIG. 9. Multitube sections, Style III.

The fintube, because of its engineering characteristics, has other advantages. Again, this is due to its fin effectiveness or fin efficiency. The LMTD in the basic Equation 1 above is based on the bulk stream temperatures of the fluids in an exchanger. It does not take into consideration any difference of temperature which may exist in the surface transferring the heat. The fin on a tube, regardless of its shape, has a temperature drop from its outermost point to the base. The fin effectiveness is a measure of this temperature gradient.

The temperature gradient, or the fin effectiveness, can work to advantage in many types of services. For example, in heating a fluid with steam in the tube, the added surface on the outside of the tube transfers the heat to the fluid in contact with the fins at lower temperatures than would be possible if bare tubes only were used. Conversely, using fintubes in contact with a product to be cooled, the cooling is done actually at higher temperatures than it would be if only bare tubes were used for such a service. All temperatures referred to are metal skin temperatures.

Mechanical design

Let's consider some of the mechanical design advantages . . .

Flexibility . . . for process changes and revamps is inherent in the equipment. It is not uncommon that before a new plant is put onstream, design changes will be made which will affect the flows, temperatures, etc., of a heat exchanger. The sectional type equipment can be rearranged and/or added to, should such a process change be made, without too much added expense in the field.

Multiplicity of services . . . is possible for interplant and intraplant exchangers because this type of standard equipment is designed for pressures of 500 to 600 psig at temperatures of 350 F to 650 F. This design range covers more than 80% of all the heat exchanger requirements in the average chemical or petroleum plant (see Fig. 4).

Standby equipment . . . for critical services, because of fouling or corrosion — or both, can be reduced considerably inasmuch as it is only necessary to install one extra parallel stream of sectional exchangers rather than another complete standby unit, as is frequently the case with single purpose type equipment.

Fig. 5 shows such an installation. It is possible to valve in one standby bank and cut out any other bank of sections for inspection, etc., without shutting down the complete exchanger.

Future plant expansion . . . can be incorporated into a process without

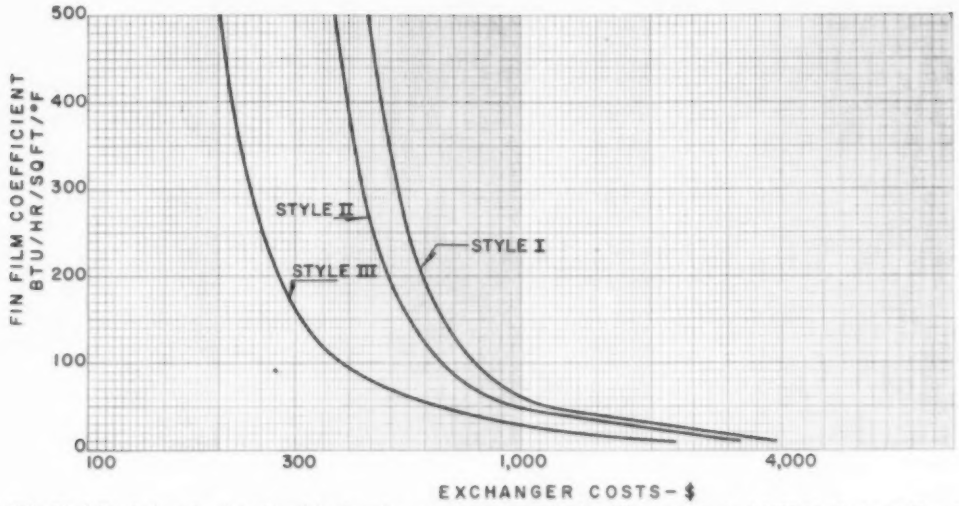


FIG. 10. Estimated costs of sectional heat exchangers, based on tubeside film coefficient of 1000 Btu/hr/sq ft/F and with carbon steel fin and shell material. $\frac{Q}{LMTD} = UA = 10{,}000$. Shell size: Styles I and II, 3-in. IPS; Style III, 4-in. IPS.

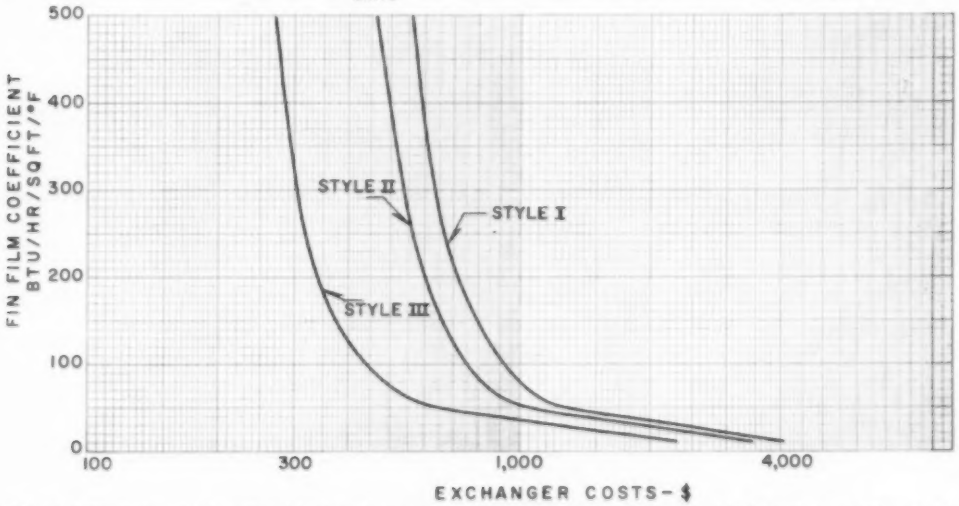


FIG. 11. Estimated costs of sectional heat exchangers, based on tubeside film coefficient of 600 Btu/hr/sq Ft/F and with carbon steel fin and shell material. $\frac{Q}{LMTD} = UA = 10{,}000$. Shell size: Styles I and II, 3-in., IPS; Style III, 4-in. IPS.

paying a premium for the heat exchange equipment. Fig. 6 shows an installation designed for two-thirds of the future plant requirement. Five sections will be placed over existing ten sections.

Standardization . . . of equipment is important, and sectional type heat exchangers offer this possibility. Replacement parts and stock inventories can be kept to a minimum. This is a particularly great advantage for plants remotely located from supply sources, or foreign installations.

Within recent months there has appeared some sectional heat exchanger type equipment which is proving to be more economical than that offered in the past. There are two general classifications:

- **Double pipe fintube** — one tube within one shell.
- **Multitube** — a finned tube bundle within one shell.

The multitube sectional equipment is more economical because the tubes utilize highly efficient fins and the section employs the cost savings of a redesigned shell.

The economics of the multitube type section again goes back to the fin effectiveness of the fintubes used.

Refer to Fig. 3, and note the higher effectiveness values for this section as compared to the straight double pipe fintube type. Curve 1 shows the fin effectiveness for the multitube fintube type which employs admiralty or brass fins. This curve should be compared to Curve 3. The carbon steel curves for the multitube and double pipe fintube are 2 and 4 respectively. The differences in fin effectiveness for a given film coefficient between these sets of curves is actually a measure of the increased scope of application which the multitube section has over the double pipe fintube type and is reflected in the economics for a given heat exchanger application.

Fig. 7 and 8 show the design comparison of the two basic double pipe fintube type sections. Fig. 9 shows the design of the multitube type section. For the sake of simplicity these are referred to as Styles I, II and III. (Fig. 7, 8, and 9 respectively.)

Estimating costs

Graphs have been developed to assist you in estimating rough costs in terms of these three styles of sectional heat

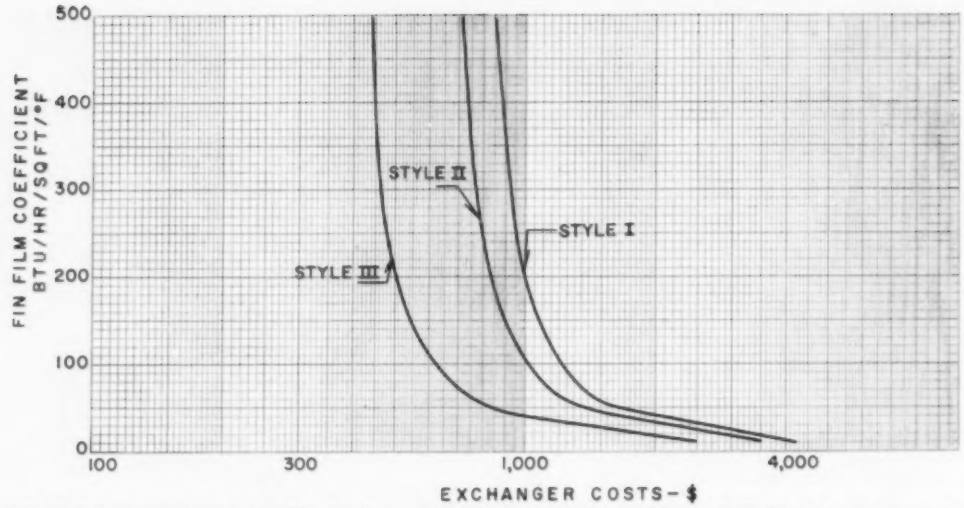


FIG. 12. Estimated costs of sectional heat exchangers, based on tubeside film coefficient of 300 Btu/hr/sq ft/F and with carbon steel fin and shell material. $\frac{Q}{LMTD} = UA = 10{,}000$. Shell size: Styles I and II, 3-in. IPS; Style III, 4-in. IPS.

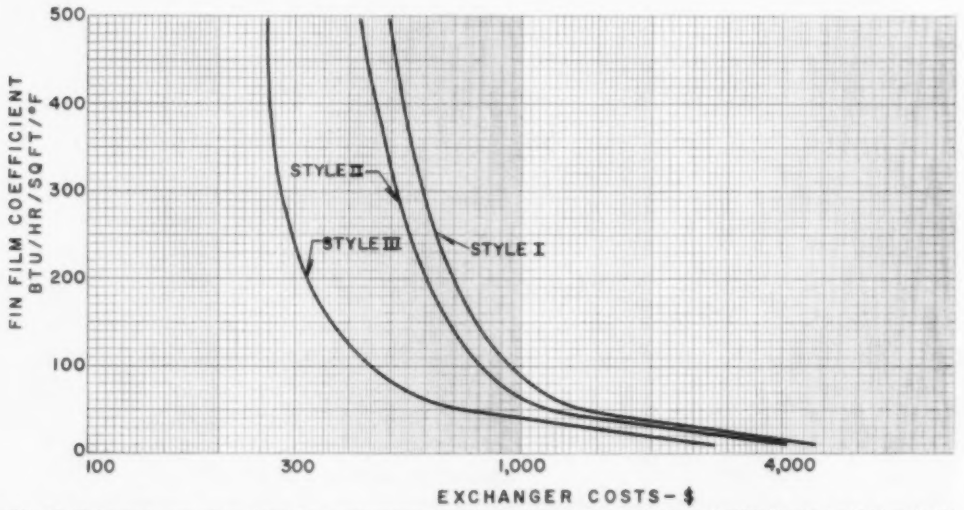


FIG. 13. Estimated costs of sectional heat exchangers, based on tubeside film coefficient of 1000 Btu/hr/sq ft/F and with admiralty fin and carbon steel shell material. $\frac{Q}{LMTD} = UA = 10{,}000$. Shell size: Styles I and II, 3-in. IPS; Style III, 4-in. IPS.

exchangers. These graphs also show by comparison the increased scope of application for Styles II and III over Style I in terms of today's selling prices for such equipment.

To use these charts you must have a fair understanding of the film coefficients to be expected for the fluids in an exchanger problem. The fluid with the lower film coefficient should be on the fin side, the other fluid in the tubes. The tubeside film coefficient and tube material will determine the chart to use for the estimation of costs for any one of these three styles of sectional equipment.

These charts are based on the following assumptions:

1. $\frac{Q}{LMTD} = UA = 10{,}000$
2. Exchanger length is the nominal 20 ft standard.
3. Styles I and II have 24 fins on a 1.9-in. OD tube in a 3 in. IPS shell.
4. Style III is a 4-in. IPS shell.

An example showing the use of this chart follows:

Service = HC Cooler
Q = 376,000 Btu/hr
LMTD = 27.6 F
Sp Gr HC = 0.5
Coolant = Water
Tubes = Admiralty

$$\frac{Q}{LMTD} = UA = \frac{376{,}000}{27.6} = 13{,}600$$

Expected film coefficients:
Water = 500-600 Btu/hr/sq ft/F
HC = 175-200 Btu/hr/sq ft/F (See Table 1)

Use Fig. 14 with a fin film coefficient of 175 to determine base costs

	Chart Costs
Style I	$490.00
Style II	680.00
Style III	920.00

These costs are based on a UA product of 10,000. The UA product for this problem, however, is 13,600; therefore, these costs should be multiplied by the ratio of the problem UA product to Fig 14 UA product (10,000) to arrive at the actual estimated costs for the exchanger.

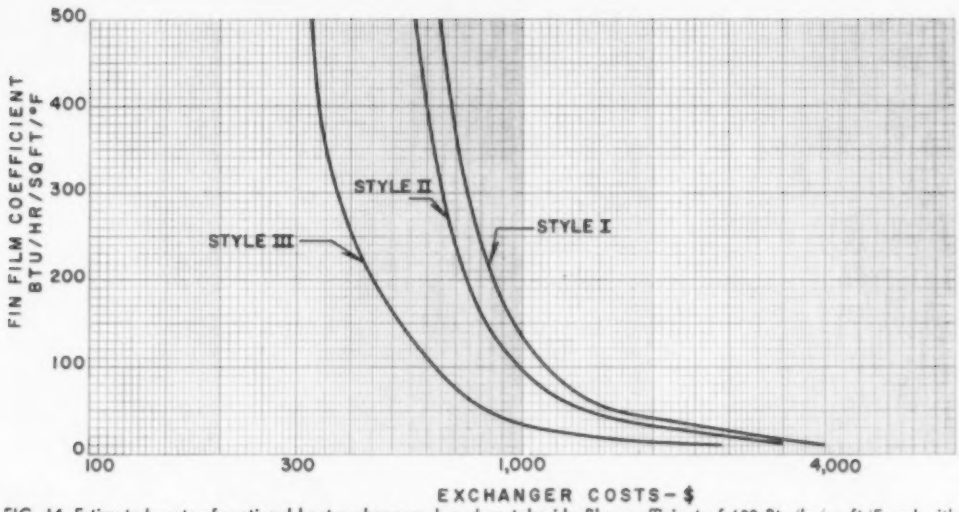


FIG. 14. Estimated costs of sectional heat exchangers, based on tubeside film coefficient of 600 Btu/hr/sq ft/F and with admiralty fin and carbon steel shell material. $\frac{Q}{LMTD} = UA = 10{,}000$. Shell size: Styles I and II, 3-in. IPS; Style III, 4-in. IPS.

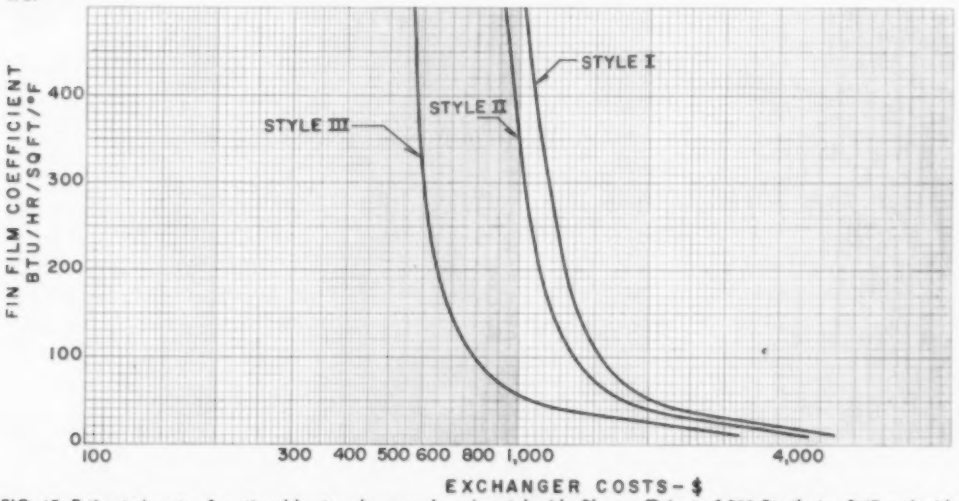


FIG. 15. Estimated costs of sectional heat exchangers, based on tubeside film coefficient of 300 Btu/hr/sq ft/F and with admiralty fin and carbon steel shell material. $\frac{Q}{LMTD} = UA = 10{,}000$. Shell size: Styles I and II, 3-in. IPS; Style III, 4-in. IPS.

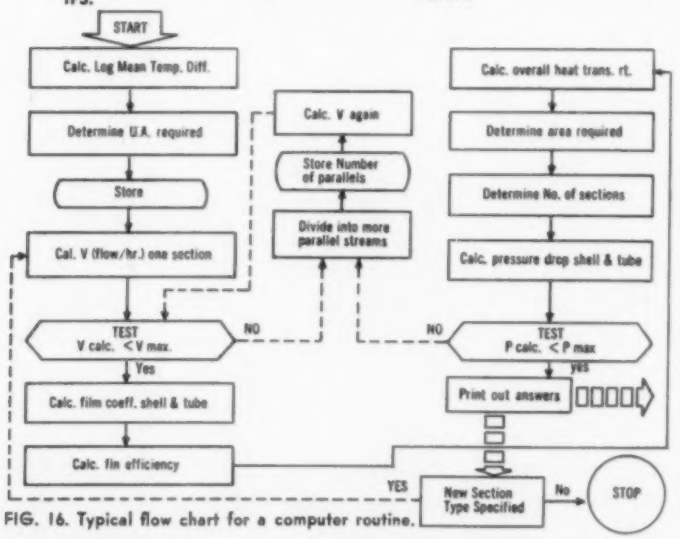


FIG. 16. Typical flow chart for a computer routine.

			Est. Costs
Style I	490.00 ×	$\frac{13{,}600}{10{,}000}$ =	$ 666.00
Style II	680.00 ×	" =	925.00
Style III	920.00 ×	" =	1,250.00

These basic charts will also give you a good indication of what additional costs are involved for the ever elusive term known as "fouling factor," which sometimes is really an unknown and is not necessarily consistent with plant experience. Pick a set of clean film coefficients for both the finside and tubeside. Estimate the costs. Then apply fouling factors to these coefficients and again estimate the costs. The difference is the cost of the fouling factor.

Estimated fin film coefficients to use for the finside of these styles of heat exchangers are given in Table 1.

Understand that the fin film coefficients are based on averages attained in actual design practices. A specific

heat exchanger problem can have limitations which would, when actually designed, make your estimate appear erroneous. **Watch out for the following:**

1. Length limitations under 20 ft for equipment.
2. Severe fouling on the streams.
3. Pressure drop limitations which are under a normal average for the specific application being considered.

On the other hand, if increased lengths of equipment can be used, the charts will be on the conservative side of any estimate.

These three styles of sectional heat exchangers also are very basic. Styles I and II can have more fins if the pressure drop conditions allow it. The addition of more fins could decrease costs by approximately 10%.

The sectional type heat exchangers also lend themselves to bare tube applications. Many are used for these types of services:

1. Extremely high pressures on the tubeside — maximum 15,000 psi.
2. Heaters and coolers requiring alloy material in contact with the process fluid.
3. Exchangers whose film coefficients are approximately the same, ie, one stream condensing, the other stream vaporizing.

The heat exchanger industry in general has gradually been thermally designing most equipment with the aid of computers. The sectional heat exchanger manufacturers are no exception to this trend.

The most economical selection of sections is also given by the computer for each heat exchanger problem because it is capable of designing into all the types of standard sectional equipment which a manufacturer has available to do a given job.

A typical flow chart for a computer routine is shown in Fig. 17. The computer actually goes through this routine for each different style of sectional heat exchanger, including the variable fin combinations of height, material, etc., which is capable of meeting your general design specifications. It further prints out the answers for these pieces of equipment on a specification sheet which is included with the quotation sent for evaluation. A typical computer output spec sheet is shown in Fig. 17.

The computer does not eliminate the experience factor of a good rating engineer acting in good faith, however, because alternate designs reflecting the rating engineer's experience can be done very quickly and included in the quotation for consideration.

Manufacturers have probably done all within their power to achieve the goals of modern design and production efficiencies. The purchasers of equipment should review their own requirements also with a view toward *"leaning out"* their specifications for equipment, particularly run-of-the-mill exchangers.

★ ★ ★

TABLE 1. Hydrocarbon Fluids.
(Sp Gr Range — 0.8-0.9)

Fluid	Visc/range	Fin film Coeff.—fouled	Fluid is heated—cooled
H.C. (Lube Oil)	16-20	15-20	C
H.C.	9-12	25-35	C
H.C.	8-10	35-45	C
H.C.	6-9	20-35	H
H.C.	4-7	20-45	C
H.C.	2-6	35-45	C
H.C. (Gas Oil)	1-2	30-55	C
H.C. (Lube Oil)	1-2	40-55	C
	Sp Gr Range 0.7-0.79		
H.C.	0.5-0.8	100-150	C
H.C. (Effluent)	0.5-0.8	40-50	C
H.C. (Naphtha)	0.3-0.4	50-70	H
H.C. (Feed)	0.2-0.3	65-85	H
H.C. (Hot Oil)	0.1-0.2	250-300	C
	Sp Gr Range 0.5-0.69		
H.C. (Bottoms Recycle)	0.3-0.5	75-100	C
H.C. (Hot Oil)	0.1-0.2	250-300	C
H.C. (Gasoline)	0.1-0.2	125-200	C
H.C. (Gasoline)	0.1-0.2	175-200	H
H.C. (Butanes)	0.1-0.2	250-300	C
H.C. (Propane)	0.1-0.2	300-400	C
	Other Fluids		
Ethylene (Gas)		85-125	H
Freon		100-150	H
Glycerine		80-125	H-C
H.C. Gas		75-125	H-C
Hydrogen		125-175	H-C
15% MEA		175-225	C
Steam (Gas)		120-150	H
Water		200-300	C

EXCHANGER SPECIFICATION SHEET

1	BFT Quotation Number	1170J
2	Date	
3	Customer Item Number	12
4	Exchanger Service	Depropanizer Bottoms Cooler

DESIGN CONDITIONS

	SHELL	TUBE	
5			Type of Fluid Circulated
6			Vapor Entering - Lbs/Hr
7	35,940	30,000	Liquid Entering - Lbs/Hr
8			Vaporized or Condensed - Lbs/Hr
9	.53	1.00	Specific Gravity at Average °F
10	.60	1.00	Specific Heat at Average °F
11	.20	.79	Viscosity - Centipoise at Average °F
12			Molecular Weight
13	.0783		Thermal Conductivity
14	142	80	Temperature in °F
15	100	110	Temperature out °F
16	250.00	55.00	Operating Pressure (Inlet) - psi Absolute
17	.0010	.0010	Fouling (Minimum)
18	899,000	Heat Exchanged - btu/hr	
19			Eng. Ref.
20			Eng. Ref.

PERFORMANCE DATA

	Section Number	Total No. Sect.	Arranged Parallel Shell	Arranged Parallel Tube	Total Surface Sq. Ft.	Lmtd Corr.	U_D Service	Pressure Drop - psi Shell	Pressure Drop - psi Tube	Velocity Ft./Sec. Shell	Velocity Ft./Sec. Tube	Engineering Reference		
*21	611-01J-420	2	2	2	598.6	25.5	58.8	3.1	1.4		3.1	101	288	464
22	014-01J-420	8	2	2	805.2	25.5	43.7	10.0	3.6		4.3	120	336	486
23	014-01J-720	6	2	2	843.9	25.5	41.7	11.2	2.7		4.3	98	350	486
24	214-01J-420	8	2	2	1446.6	25.5	24.3	2.0	3.6		4.3	110	202	486
25														
26														
27														
28														

29 SPECIAL REQUIREMENTS

This item (*) is the most economical one.

SPECIAL				STANDARD			
Shell	Tube		REMARKS	Shell, Steel 1/8 in. Corr. Allow.		Tube	
	Corr. Allow.			With 2-1/2" Adm. Tubes	With All Other Tubes	Steel	Admiralty
			Design Press. PSIG	325	500	500	500
			Metal Temp. °F.	650	650	650	300

SEE REVERSE SIDE FOR CONSTRUCTION DETAILS

Form EC-94A
Sept. 1959

FIG. 17. Typical computer output specification sheet.

DU PONT *Petroleum Chemicals* NEWS

Number 104 in a series of bulletins for the Petroleum Industry

SEPTEMBER • OCTOBER 1960

Foam killer finds new uses in gas scrubbing

The primary use of DuPont's OCENOL® anti-foaming agent in the petroleum industry has been as a foam-breaker in the Girbotol process.

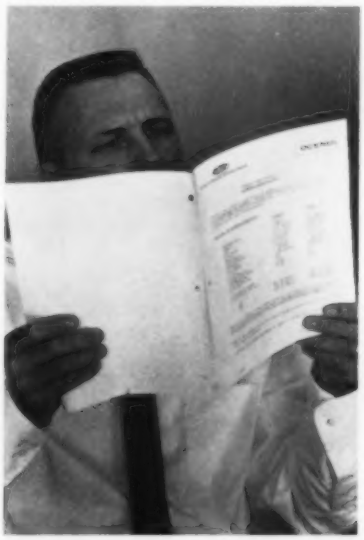
Now OCENOL is finding increasing use in atmospheric and vacuum distillation processes. Full-scale use in several such operations indicates that it is one of the most effective anti-foam agents available for the job.

And it has cost-saving advantages, too. OCENOL carries a low price tag, works effectively in concentrations of 0.1 to 0.3 lb. per 1,000 barrels. The result is that on a performance basis you pay a very low price to break foam with OCENOL.

What OCENOL is

OCENOL is a technical grade of oleyl alcohol rich in cetyl and unsaturated C_{18} alcohols. It is available in two forms: OCENOL and OCENOL P. OCENOL P contains a lower proportion of unsaturates than OCENOL. In some applications, the products can be used interchangeably.

OCENOL may be the answer to your foaming problem. Write direct to Wilmington for technical data, or contact your Du Pont Petroleum Chemicals representative.



How to stop paying for sludge in distillate and residual fuels

One shovelful of sludge. Looks like so little. *Yet you pay for it three times* in the marketing of a distillate and residual fuel.

You pay for downtime and labor when storage tanks must be desludged. You pay for lost product. You pay for excessive filter and strainer replacement, or for handling complaints from customers who have these problems.

This is money you do not have to spend. Care in handling, in the blending of fuels and in the use of proper additives will save you this money. To overcome sludge, add Du Pont Fuel Oil Additive No. 2 to your product. For every 1,000 barrels of residual or diesel fuel, you need only a small amount of Du Pont FOA-2 – usually 5 to 15 pounds. This stabilizes, solubilizes, disperses and keeps insoluble particles in suspension so they won't form residue.

You get just as much burnable fuel *out* of the storage tank as you put *in*, with nothing lost to sludge.

Customer Benefits. In diesel fuels, FOA-2 eliminates or greatly reduces filter plugging and injector sticking. One user reported that filter life doubled on heavy roadbuilding equipment with subsequent savings in labor, downtime and filter replacement.

Being nonmetallic, FOA-2 burns right along with the fuel, leaves no ash or other deposit. Does not contribute to sparking problems.

In residual fuels, FOA-2 prevents or reduces tank sludging, burner fouling, and strainer and heat exchanger clogging.

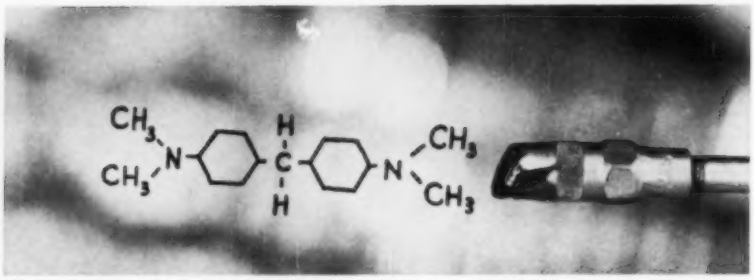
The Science of Sludge. The petroleum industry has used Du Pont FOA-2 in millions of barrels of diesel and residual fuel since its introduction nine years ago. At Du Pont, sludge formation, prevention and removal has become a science, and our experience is available to help you improve the flow and burning properties of your product. Call or write for our bulletin on FOA-2, or for consultation on sludge prevention.

ADVERTISEMENT—Prepared for the Petroleum Chemicals Division of E. I. du Pont de Nemours & Company (Inc.)

OVER

DUPONT *Petroleum Chemicals* NEWS

New way to stabilize your grease and oils



Oxidation is, of course, one of the bitterest enemies of the grease and oil you produce.

The problem looks simple on the surface: use an antioxidant.

But what complicates it is *cost*. Profit margins don't permit you to pay so much money for additives that your product ends up with a price tag that's out of line with competition.

Answer from Du Pont

Now there's a way out of this problem. Currently available is a Du Pont antioxidant that effectively stabilizes greases and lubricating oils, protects them from oxidation, *yet is used in small concentrations.*

Called ORTHOLEUM 304, this product is an antioxidant with one of those jawbreaking chemical names you like to roll around on your tongue: 4, 4' tetramethyldiamino-diphenylmethane.

ORTHOLEUM 304 is a light grayish granular solid, with excellent storage stability. Melting point: 190°F. Bulk density: approx. 5 lb./gal. Supplied in 47-gallon fiber drums containing 200 pounds net.

Samples available

If you want smooth, uniform texture, even when your grease or oil has been stored for a time, look into the economy of ORTHOLEUM 304. The broad uses of this antioxidant are illustrated by 17 references contained in our literature. Ask your Du Pont Petroleum Chemicals Division representative for details and a sample, or write direct to Wilmington, Delaware.

CHICAGO DISTRICT MANAGER

JAMES M. MOSTYN is manager of the Chicago District, Du Pont Petroleum Chemicals Division.

Prior to joining Du Pont in 1948, Jim worked in the petroleum additives field for several years. During his service with the Corps of Engineers of the U. S. Army, he was assigned to various duties in North Africa, Italy, and France, for which he received four battle stars and a Bronze Star.

His first assignment with Du Pont was in the Central Region Laboratory of the Petroleum Chemicals Division. By 1958 he had become manager of the Chicago District office.

His work with Du Pont's Petroleum Chemicals Division has covered laboratory, safety, construction and sales, which explains why Jim is especially qualified to give technical help to users of Du Pont tetraethyl lead and our other petroleum additives.

A native son, Jim lives today in the same town in which he was born, Summit, Illinois. At home his life centers around (a) his wife, Lorraine, three daughters and two sons, (b) his golf clubs and (c) his fine pipe collection. Next time you're passing by 8 South Michigan Avenue in Chicago, stop in for a chat. You choose the subject . . . petroleum, putts, pipes or potpourri.

Heard about Du Pont's new "hush hush" dye?

Du Pont's new Oil Color IA has been created to identify products which, for various reasons, you choose not to give a distinctive color.

It's an undercover dye, an identifying agent (IA). Though it adds no appreciable color to your product, you can easily detect its presence by simple tests.

For example, a few drops of gasoline or kerosine containing 0.5 to 1.5 grams of Du Pont Oil Color IA per 100 gallons will immediately produce a blue spot on a paper towel.

Smaller concentrations – as little as 0.03 grams per 100 gallons – can be detected by shaking the gasoline with a little methanol and acid water and observing the color of the methanol layer.

Purpose? You can solve many special problems with this unusual dye, including: coding products to determine source, brand or grade; identifying gasolines for tax purposes; controlling proper use of products; deterring pilferage.

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Dr. J. M. Marchello, Oklahoma State University

ALGEBRA | part 5

TRADITIONAL CHOICE of the adjectives *real* and *imaginary* to describe numbers in algebra is unfortunate. They merely serve to distinguish between two kinds of numbers, neither of which is more "imaginary" than the other. As indicated in Article 3, the ordinary rules of addition, subtraction, multiplication, and division apply to complex numbers. In electric-circuit analysis, engineers customarily use the symbol j in place of i.

G. Geometric Interpretation of Complex Numbers

The basic principles of vectors can be used to increase our understanding of complex numbers. The geometrical interpretation consists of representing the complex number $z = x + iy$ by the point in the plane with rectangular coordinates x, y.

From Fig. 1, it is seen that the real part of z is its x-coordinate, and the imaginary part is its y-coordinate. If $z = x + iy$, the number $\bar{z} = x - iy$ is called the conjugate of z. The distance, ρ, of the point, z, from the origin is called the modulus of z, $\rho = z = \sqrt{x^2 + y^2}$. The angle between the positive direction of the x-axis and the line Oz is called the angle of z, and in Fig. 1 is denoted by ϕ.

Consideration of Fig. 1 indicates that complex numbers may also be expressed in polar coordinates in the usual vector form. This important fact will be of considerable use in our later discussion of calculus and differential equations.

H. Probability

The laws of probability are involved in the background of all statistical calculations. In order for an engineer to apply statistics to data it is not necessary that he be thoroughly familiar with all the mathematics of probability theory.

In a given situation, if N events can occur and n of them result in a new situation A, then the probability of A occurring in any single event is

$$P(A) = \frac{n}{N} \quad . \quad . \quad . \quad . \quad (1)$$

Probability is expressed as a fraction between 0 and 1. An event that is certain to occur has a probability of 1, and an impossible event has a probability of 0.

If two or more events can occur and their individual chances of occurrence do not affect each other, the probability of them all occurring is equal to the product of all the separate probabilities.

$$P(A_1, A_2, A_3 \ldots) = P(A_1) \cdot P(A_2) \cdot P(A_3) \ldots \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

An application of this principle occurs in the analysis of rocket performance. For example, if a certain ICBM has 100 component parts, each of which has a 0.995 probability of performing correctly, the probability that the missile will fire successfully is

$$P = (0.995)(0.995) \ldots = (0.995)^{100} \quad . \quad (3)$$

taking the logarithm of Equation 3

$$\ln = 100 \ln(0.995) = -100(0.0050) = -0.50 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

now taking the anti-logarithm of Equation 4 gives

$$P = 0.606 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

Thus the hypothetical rocket has a 0.606 probability of operating successfully. That is, on the average, three out of five launching attempts will be successful.

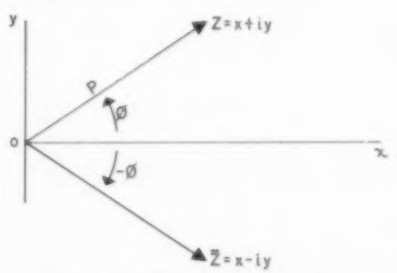

FIG. 1. Graph of a complex number.

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PETRO/CHEM

PROBLEM 7

Voltage Relationship for a Temperature Sensing Element

A new material has been proposed for use as a temperature sensing element. The resistance of an experimental element constructed of the new material has been found to vary exponentially with temperature. In the proposed bridge circuit the inbalance emf for the element has been found to obey the relation

$$V = 4.164\, e - \frac{85.33}{T}$$

where V is in millivolts and T is in degrees Kelvin.

What voltage would correspond to a temperature reading of 700 C? Suggest a simple relation to be used in correlating emf and temperature in the temperature range of 700 C to 900 C.

Solution to September Problem:

Problem 6. Liquid Level Controller

If the neutral control zone is centered in the 6-in. region, to be controlled the instrument must respond during a liquid level change of 2½ in. in the column. The time required for the increase or decrease in the column level would be

$$\Theta = \frac{\pi D^2 h}{4\Delta L}$$

For normal column operation the bottoms flow rate is not expected to deviate by more than a few percent. An extreme deviation of 10% in the bottoms rate would empty or fill the upper or lower response span of 2½ in. in:

$$\Theta = \frac{\pi \times 3^2 \times \frac{2.5}{12}}{4 \times 12 \times \frac{1}{7.48} \times \frac{1}{60}} = 55 \text{ seconds}$$

The level controller can respond rapidly enough to handle the anticipated flow rate fluctuations.

A 6-in. line is reasonable for the low linear flow rates usually occurring in pipes handling bottoms products. As a check:

$$V = \frac{L}{A_p} = \frac{120 \times \left(\frac{1}{7.48}\right) \times \left(\frac{1}{60}\right)}{\left(\frac{\pi}{4}\right) \times \left(\frac{6}{12}\right)^2}$$

$$V = 1.36 \text{ ft per sec}$$

A linear velocity of 1.36 ft per sec in the bottoms line is somewhat high but will not cause any great deal of difficulty in operating the column under the proposed conditions.

The pressure drop across the flow control can also be an important part of the column operations. If the friction loss of the valve is assumed to have an average value equivalent to 300 pipe diameters, the 6-in. valve causes the same pressure loss that 150 ft of pipe would. The pressure drop in terms of the Fanning friction factor is:

$$\Delta p = \frac{fV^2 \rho l}{2gD}$$

The Reynolds number of the bottoms liquid under normal operation will be

$$N_{Re} = \frac{DV\rho}{\mu}$$

Where: $\mu = 0.25$ centipoise
$\rho = 54$ lb/ft^3

$$N_{Re} = \frac{1}{2} \times 1.36 \times 54 \times \frac{1}{0.25} \times \frac{1}{0.000672}$$

$$N_{Re} = 248000$$

From the von Kármán equation

$$\frac{1}{\sqrt{f}} = 4.0 \log_{10} (N_{Re} \sqrt{f}) - 0.40$$

$$\frac{1}{\sqrt{f}} = 4.0 \log_{10} (2.48 \times 10^5 \sqrt{f}) - 0.40$$

This expression is transcendental and cannot be solved by the usual algebraic methods. Using a trial and error method the following table was constructed.

f Assumed	Left side	Right side
0.003	18.3	16.1
0.004	15.8	16.4
0.0037	16.4	16.3

Then the pressure drop across the valve is

$$\Delta p = \frac{0.0037 \times (1.36)^2 \times 54 \times 150}{2 \times 32.2 \times (1/2)}$$

$$\Delta p = 17 \text{ psi}$$

The estimated pressure drop across the control valve of 17 psi is roughly five times higher than is normally used. The above calculations are based on a gate valve design and the pressure drop characteristics may well be 10 times higher than those of the control valve. The manufacturer's data on the characteristics of the valve should be obtained and used to determine a better estimate of the pressure drop across the valve. It may be necessary to change the float and seat design to obtain a reasonable pressure loss.

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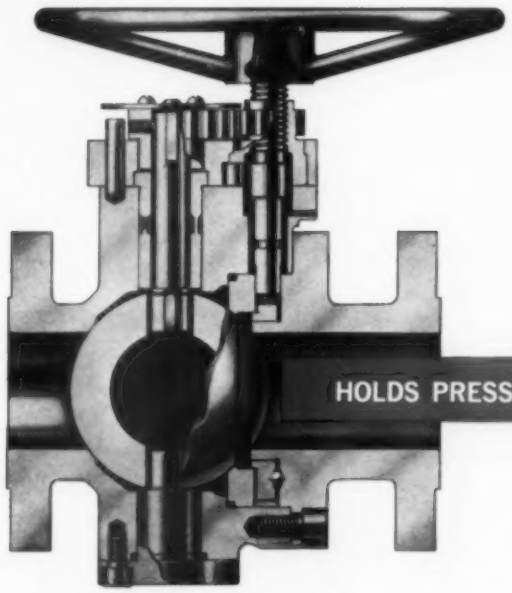

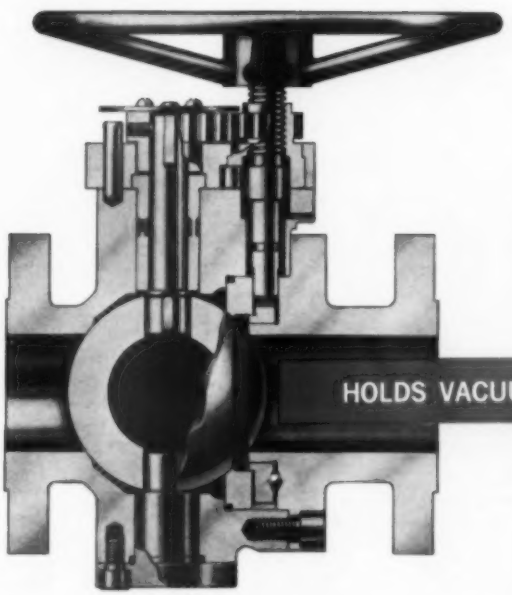

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The spherical plug is mounted on accurately positioned bearings, maintaining a minimal controlled clearance between plug and body. This contributes to easy, free-turning operation as well as to long service life.

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Hydril valves are available in a wide range of sizes and ratings. Worm-gear and motor-operated models can be supplied. Get the full story on Hydril Valves from your nearby representative . . . or write Hydril Company for free Catalog No. V-60.

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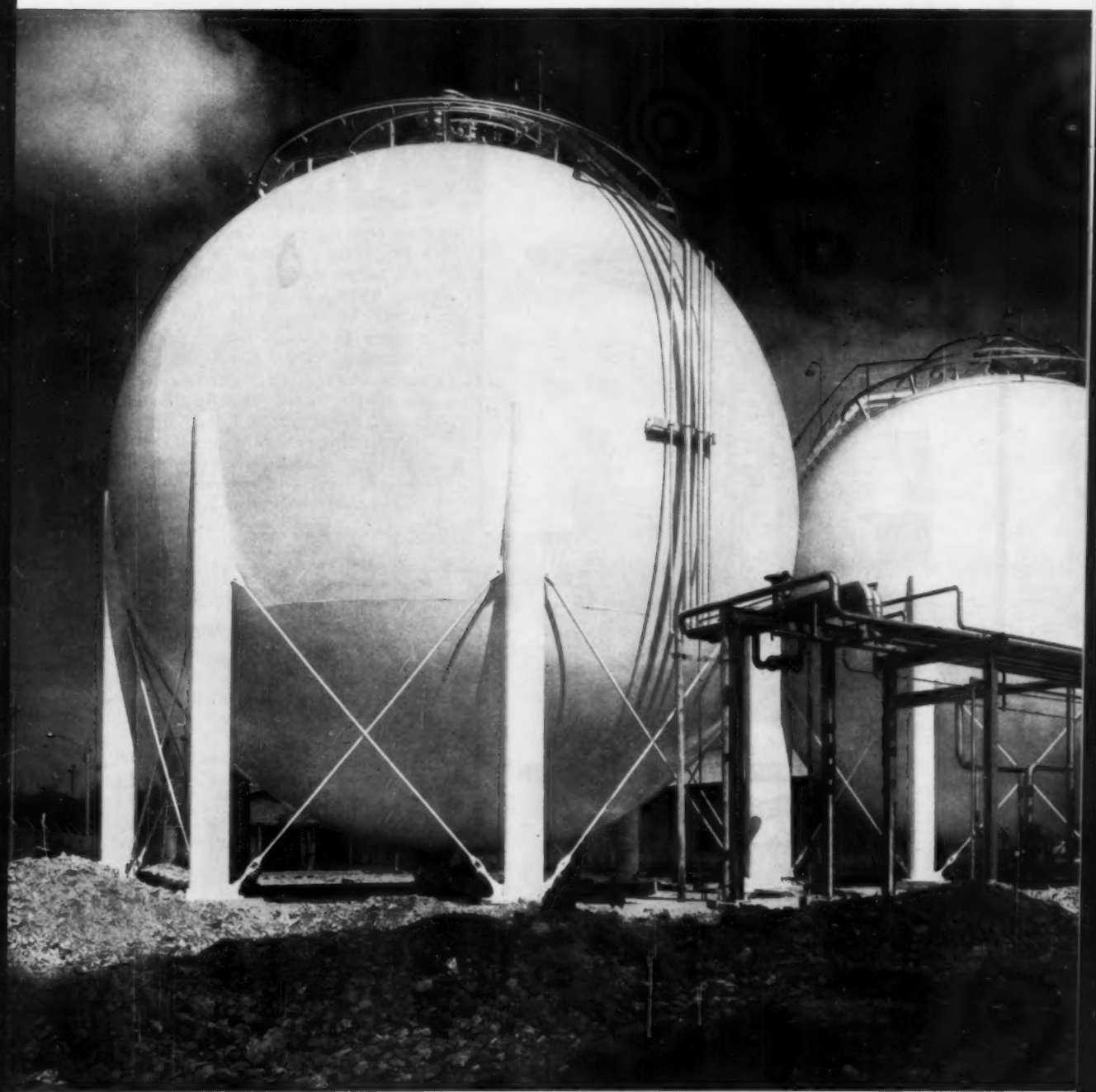

Hortonspheres built of USS "T-1" Steel for Compania Cubana Del Nitrogeno, S. A., Matanzas, Cuba. Designed, fabricated and erected by Chicago Bridge & Iron Company.

This mark tells you a product is made of modern Steel.

Weight cut 50%

in USS "T-1" Steel pressure vessels

Each of these two Hortonspheres in Matanzas, Cuba, has a capacity of 8,750 barrels of anhydrous ammonia. They are 45.5 feet in diameter and each shell weighs about 311,350 pounds. By designing them with USS "T-1" Constructional Alloy Steel, to an allowable working stress of 32,400 psi, the plate thicknesses were reduced to 1.109 inches and 1.075 inches. This is about 50% less than if A212-Grade B fire box quality steel had been used.

Result: Only 363 tons of USS "T-1" Steel were needed for both tanks, reducing by one-half the amount of steel that would otherwise have been required. Freight, handling, welding and erection costs were less—and the user got a stronger, tougher vessel with an overall saving in cost.

Fabrication steps: Plates of USS "T-1" Steel in widths of 78 inches and 115 inches, and in lengths up to 19 feet 2-1/2 inches, were shaped cold and field stress relieved. Column plates and some shell plates were stress relieved in the shop. Electrodes used in field welding were low hydrogen type of the E110 strength level and all field welds were 100% radiographed. With a minimum yield strength of 100,000 psi, plus toughness, weldability, and high resistance to impact abrasion, USS "T-1" Steel is ideally suited for many applications throughout industry. Write for our latest booklet. United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania. *USS and "T-1" are registered trademarks*

Hortonsphere is a registered trademark of Chicago Bridge & Iron Company

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PETRO/CHEM
new equipment

PROBLEM

SOLUTION

Quick release single half coupling saves time, connects dissimilar flanges easily

A new standard in marine terminal equipment of interest to design engineers responsible for such installations is the new Model QD-16 quick release single half coupling to connect dissimilar flanges. It is said to eliminate use of bolts, nuts, gaskets . . . can easily be adjusted to accommodate variations found in foreign counterparts of American flanges. Complete operation, including alignment, engagement, and sealing, can be accomplished safely and without time lost searching for special adapters or spool pieces. Here's how it works:

Unit is positioned so latches engage the mating flange. As operating handle is rotated, latches contract concentrically upon the flange and impart an axial pull to the hose until seal is properly made. Reversing rotation of the handle disengages the coupling quickly. A hydraulic device may be included for remote hook-up or disconnect. A simple presetting of the latches to selective positions accomplishes any necessary adjustment for deviations from standard dimensions in thickness or diameter.

Coupling answers these design criteria:

Safety	Positive locking
Adaptability	Quick release
Ease of operation	Low pressure drop
Versatility	Compactness
Positive sealing	Structural soundness

Efficiency in reducing time requirements for connecting and disconnecting flanges results in lower operating cost and less tanker turnaround delay. Coupling also finds application in many areas of refinery and petrochemical plant fluid handling facilities where quick coupling and disconnect are required. *Flight Refueling, Inc.*

Circle number (41) on reply card.

Bamboo slide rule lubricates self, won't shrink or warp

Laminated bamboo slide rule is self lubricating, shrink and warp resistant. 10-in. model has log-log scales which give equivalent accuracy of an 80-in. rule. Has overlapping scales and more usable scales — 26 — than any other slide rule on market. Comes with leather case and instruction book. 5-in. model also available. *Rulco, Inc.*

Circle number (42) on reply card.

Heavy duty air compressors

Two compact heavy duty air compressors just introduced have new water cooling design that affords more efficient use of power. Available are 2-stage LB model for pressures to 1000 psi and single-stage LA model for pressures to 125 psi. *Gardner-Denver Company.*

Circle number (43) on reply card.

Three new firebrick lines

KAO-HB, high burn superduty; KAO-60, 60% Alumina, and KAO-70, 70% Alumina, new lines of firebrick, are now on the market. *Babcock & Wilcox.*

Circle number (44) on reply card.

Conduit fittings in copper-free and copper-bearing aluminum

New die cast conduit fittings, are available in both copper-free and copper-bearing aluminum. Series OR, specification grade, copper-free Pylets and blank covers have PEC-9 epoxy coating applied after Iridite treatment for protection against salt spray, acid fumes, strong caustics, and organic liquids. Series N, standard grade, copper-bearing aluminum Pylets and blank covers have Alkyd-Melamine finish. *The Pyle-National Company of Chicago.*

Circle number (45) on reply card.

Custom-designed control panel protected against humidity

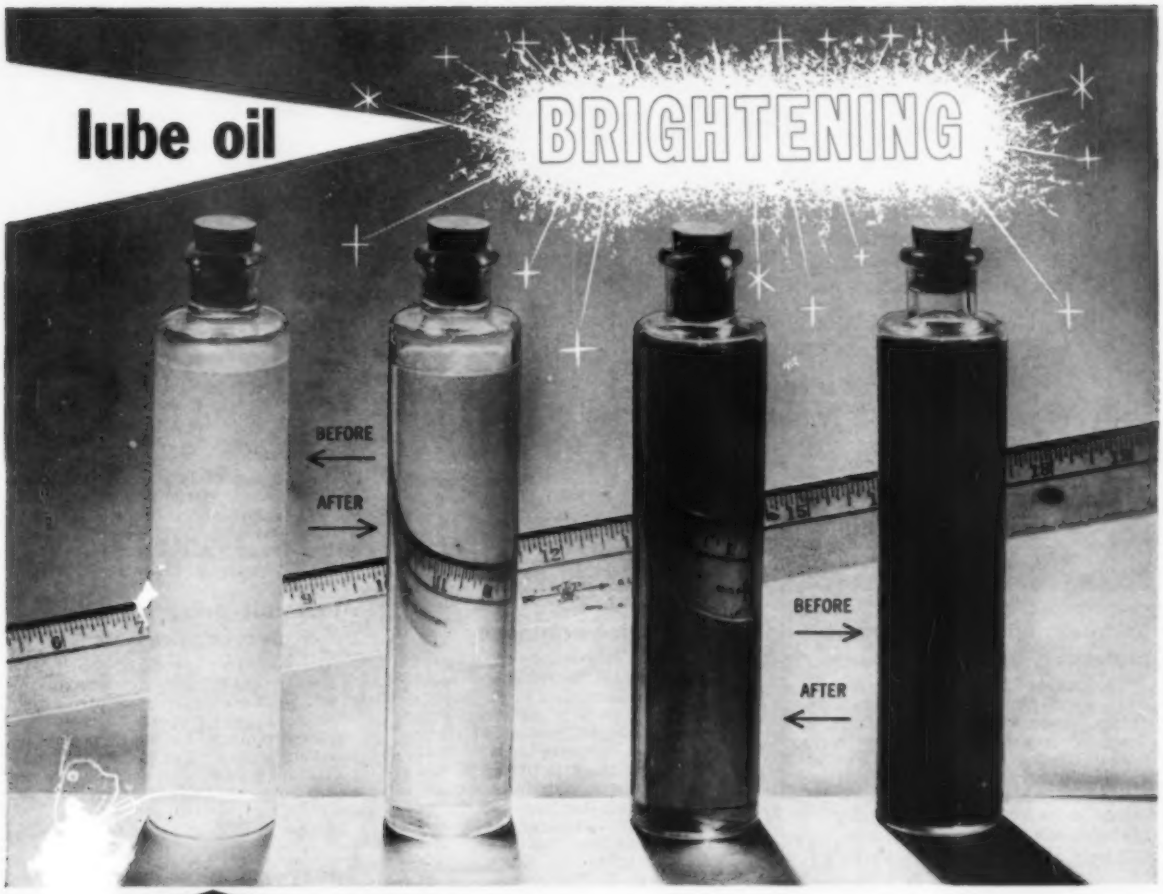
Custom-designed panel to control three multiple-fuel-fired, 100,000 lb per hr steam generating units for refinery in the Philippines is wrapped in plastic with a moisture absorbing material to provide an interior that remains 100% moisture-free. *Hagan Chemicals & Controls, Inc.*

Circle number (46) on reply card.

Centrifugal pumps

New Series N1000 line of pumps are furnished both as straight centrifugal and self-priming. Available either close coupled to electric motor or pedestal mounted for user coupling to electric motor, gas, or diesel engines. Made in capacity up to 550 gal per min and head pressure to 170 ft. *Hydropump, Inc.*

Circle number (47) on reply card.



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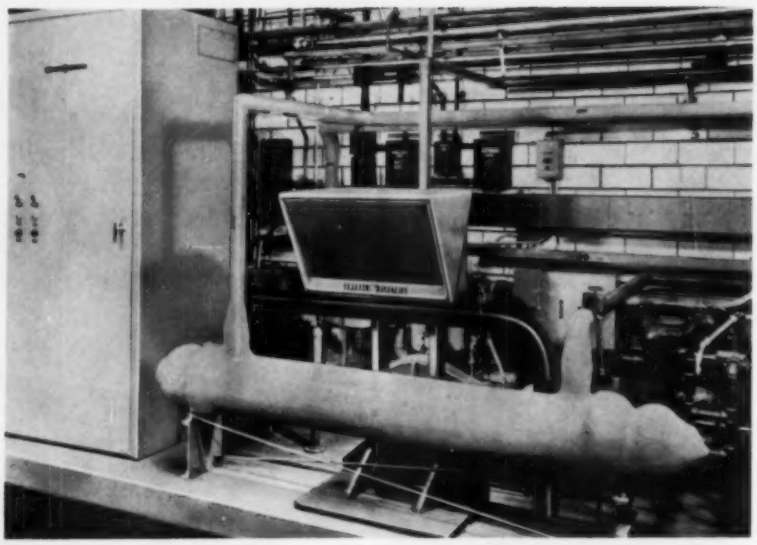

Spray-on epoxy resin offers protection against corrosion

"Skotchkote" 101, a 1-part, powdered, 100% epoxy resin, can be sprayed on pipe fittings, supports, etc., with portable, inexpensive equipment. The uniform, smooth coating cures in less than 60 sec. Provides practical means of applying corrosion protection to fittings prior to their arrival in the field. *Minnesota Mining and Manufacturing Co.*

Circle number (48) on reply card.

Unique new ball valves employ principle of rotating seats

Each operation of new type ball valve partially rotates the seat to change the relation of the mating surfaces and to provide a continuous reseating action. Has no bonnets, gaskets, or joints. Requires no lubrication to seal bubble-tight. Available in 2 to 36-in. sizes for 150 through 600-lb ASA classes and in 2 through 6-in. sizes of API 1000 psi to 5000 psi working pressure rating. *Cameron Iron Works, Inc.*

Circle number (49) on reply card.

Filled nylon piston wear rings

Filled nylon, now being used to fabricate piston wear rings for use in heavy hydraulic cylinder applications, has excellent wear resistance and requires no lubrication. It has a wide temperature range, remaining serviceable up to 350 F; has a low coefficient of friction, and will not gall cylinder walls on long stroke pistons where canted reciprocation may be encountered. *Garlock Inc.*

Circle number (50) on reply card.

Electronic alarm rotameters

Alarm rotameters measure fluid rate of flow and indicate abnormal high or low flows by electronic detection. Will activate a warning light or alarm device and will start or stop a pump, motor, or control unit. *Schutte and Koerting Company.*

Circle number (51) on reply card.

Recording refractometer

Recording differential refractometer makes practicable measurement of extremely small differences in the index of refraction of liquids in process monitoring, quality control, pilot plant studies, etc. Instrument measures index of refraction changes as small as 0.0000007 index of refraction units. Analyzer section is mounted within a standard strip chart recorder, thereby combining an analyzer and recorder in one unit. *Waters Associates.*

Circle number (52) on reply card.

Corrosion inhibitors

Two new protective coatings now on the market are Columbia 7, designed for use as a tank lining under continuous caustic service, and Polyvinyl Chloride Plastisol, inhibitor of atmospheric corrosion. Plastisol, when bonded to metal, is corrosion and abrasion resistant even when exposed to acids, bases, salts, fumes, and salt spray. *Nowery J. Smith Co.*

Circle number (53) on reply card.

Corrosion resistant fitting

New Ridg-lok tube fitting of Type 316 stainless steel is designed for medium pressure corrosion resistant service; is compatible with any fluid for which Type 316 stainless steel tubing is used, and also can be used with polyethylene, nylon, and other plastic tubing. Comes in sizes 2 through 16, for tubing of ⅛ through 1 in. OD. *Parker Fittings & Hose Division, Parker-Hannifin Corporation.*

Circle number (54) on reply card.

New Viton compound

Haveg Grade 16075, new compound based on duPont's Viton Bpolymer, is approved under MIL Spec 25897C covering high temperature, oil and fuel resistant elastomers. Formulated to provide superior compression set resistance under severe operating conditions. Resistant to ozone, oxidation, weathering, flame, and corrosive acids. *Haveg Industries, Inc.*

Circle number (55) on reply card.

X-ray emission gage permits continuous on-line analysis

♦ X-ray emission gage simultaneously and continuously checks presence and amount of up to five elements with a reference, and six without a reference, from aluminum up through the periodic table. Provides graphic, on-line analysis of the material's composition, whether in the form of liquid, slurry, or solid as dry or moist powders or sheets. Individual samples of the same materials also can be analyzed. *General Electric X-Ray Department.*

Circle number (56) on reply card.

Bevel gear operator

New "Converto-Gear Operator" provides power-assist in opening and closing iron and steel OS&Y and non-rising stem gate valves with stem diameters of 2½ in. or less. Can be supplied with new valves or ordered separately and installed in the field on present Crane valves. Adaptable for either pneumatic or electric power wrench operation. Uses bevel gear with 4.11 to 1 ratio. *Crane Co.*

Circle number (57) on reply card.

Automatic panel controls up to five compressors

New multi-unit, automatic panel serves as a single control point for operation of as many as five electric motor driven compressors. Keeps in operation only those machines required for the immediate demands of process air or gas. Permits manual or fully automatic operation of any one or all compressors in the group. *Clark Bros. Co.*

Circle number (58) on reply card.

Epoxy-insulated motors

"Epa-Seal" epoxy insulation system protects motors from corrosion . . . has high thermal stability. Motors can operate continuously in extremely moist atmosphere with no risk of electrical failure. *Elliott Company.*

Circle number (59) on reply card.

Custom-made control panels

Precision-made control panels for instrumentation and automatic control systems are custom fabricated according to the client's fabrication. Baked-on enamel finish. *I & C, Inc.*

Circle number (60) on reply card.

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PETRO/CHEM new literature

ABC's of Penton . . . gives new corrosion resistance data on Penton, together with an up-to-date report on Penton pipe. This revised edition includes new ratings at 250 and 150 F and lists more than 80 additional chemical reagents. *Hercules Powder Company.*

Circle number (73) on reply card.

Acetonitrile information . . . reactions, physical properties, information on specific uses, and a bibliography of 134 references are included in new 56-page guide book. *Sohio Chemical Company.*

Circle number (74) on reply card.

Aliphatic organic chemicals . . . more than 200 fatty acids and fatty nitrogen derivatives are covered in new catalog. *Armour Industrial Chemical Company.*

Circle number (75) on reply card.

Chemical resistance of three polyester resins . . . how bisphenol-A, isophthalic, and general-purpose polyester withstood a 6-month immersion in various corrosive aqueous solutions at elevated temperatures is revealed in a technical report. *Atlas Powder Co.*

Circle number (76) on reply card.

Compressor selection bulletin . . . features a 6-step "do-it-yourself" performance calculation method which permits selection of the proper single-stage compressor for most applications. Bulletin P-13. *Elliott Company.*

Circle number (77) on reply card.

Condulets for corrosive locations . . . are discussed in 20-page Bulletin 2699, which lists corrosive substances in tabular form along with appropriate corrosion-resistant metal and finishes used. *Crouse-Hinds Company.*

Circle number (78) on reply card.

Correlation and optimization of chemical kinetics models with the DYSTAC analog computer . . . is detailed in 26-page report, Form 80-105-003, which tells of a new and rapid procedure. *Computer Systems, Inc.*

Circle number (79) on reply card.

Dry scrubbers . . . which use centrifugal force to separate solid and liquid particles from gas . . . are described in Bulletin 7-50, which gives diagrams and capacity formula. *Peerless Manufacturing Co.*

Circle number (80) on reply card.

Electrically weldforged steel grating . . . is detailed in new brochure. *Kerrigan Iron Works Company.*

Circle number (120) on reply card.

Float valve bubble trays . . . are described in a brochure dealing with fundamentals of design and operation, mechanical features, operating results, and general design arrangement. *Nutter Engineering Company.*

Circle number (121) on reply card.

Forged steel needle valves and fittings . . . for heavy duty service to 5000 psi . . . are discussed in Bulletin 420. *American Meter Company.*

Circle number (122) on reply card.

Gas chromatograph . . . Model 15, a precise, flexible instrument that is small in size and low in cost, is described in Product Data File LOE-3. *Loe Engineering Co.*

Circle number (123) on reply card.

Gas turbine . . . Model 720/722, a 1000-hp, 300-lb unit for industrial and marine applications, is subject of Bulletin SAE-109A. *General Electric Company.*

Circle number (124) on reply card.

High-vacuum distillation equipment . . . is subject of profusely illustrated 16-page brochure. *Consolidated Vacuum Corporation.*

Circle number (125) on reply card.

Kaylo-Klad pipe insulation . . . jacketed in embossed aluminum . . . is introduced in new brochure. *Owens-Corning Fiberglas.*

Circle number (126) on reply card.

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How It Works!

The unit is positioned so that the latches engage the mating flange. As the operating handle is rotated, the latches draw the mating flanges together. Seal and lock are automatic functions. This new hose coupling eliminates the use of bolts, nuts, and can be easily adjusted to accommodate the variations found in foreign counterparts of American flanges.

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Brochure on Construction and Operation of the *QD-16 Coupling* is available. Request on your company letterhead.

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the American Institute of Chemical Engineers announces...

A.I.Ch.E. PETROCHEMICAL AND REFINING EXPOSITION!

For some time, the A.I.Ch.E. has been aware of an increasing demand for a petrochemical and refining exposition... to bring together in one place the seemingly inexhaustible number of *new* developments and new ideas associated with this dynamic and expansive field... and to put it into its proper focus in the overall chemical and petroleum picture.

NOW— for the first time in history—this show becomes a reality!

THE TIME: FEBRUARY 26—MARCH 1, 1961

THE PLACE: NEW ORLEANS, LOUISIANA

will you be there? This is *one* exposition you should not miss, for it will bring together under one roof some of the most important developments in the field... developments that you, as a chemical or petroleum engineer, should know about in intimate detail.

Sponsored by the American Institute of Chemical Engineers, the first Petrochemical and Refining Exposition will be held in conjunction with a national meeting of the A.I.Ch.E. Exhibits will be at the Municipal Auditorium, and meetings will be held there as well as at the Roosevelt Hotel. Fabled New Orleans is the ideal site for this important show—for 85% of the petrochemical industry and 35% of the refining industry are within a radius of a few hundred miles.

Several hundred exhibitors will display their products and services, with equal space being planned for both petrochemicals and refining. Papers presented at the meeting will be among the most important of the year, and will be released simultaneously to all publications. And for a big "plus," many interesting plant trips in the vicinity are being planned for you to attend.

The tentative program will feature sessions on kinetics, petrochemicals, future of the industry on the Gulf Coast, solids, future processing technology in the petroleum industry, liquid-liquid extraction, education and professionalism and many other important subjects.

PLAN YOUR TRIP TODAY!

Hotel space is certain to be at a premium for this unusual show, so we suggest an early reservation. Contact the American Institute of Chemical Engineers, 25 West 45th Street, New York 36, N. Y. for details and further information.

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Literature (Continued)

Ninety-four organic and inorganic chemicals . . . are reviewed in newly revised and enlarged 16-page reference digest, Bulletin 100-D. *Hooker Chemical Corporation.*

Circle number (127) on reply card.

Painting guide . . . for industrial plants, machinery and equipment, and commercial and institutional buildings . . . discusses the different uses for various types of primers and finish coats and shows samples of colors available. 24 pages. Full color. *Sherwin-Williams Co.*

Circle number (128) on reply card.

Plastic stock shapes, molded and fabricated parts . . . are detailed in 16-page catalog, Bulletin AD-177, which contains photographs and specifications for units manufactured from Teflon, CTFE, Delrin, Nylon, and other resins. *Garlock Inc.*

Circle number (129) on reply card.

Pocket selecter guide . . . handy 3 x 7-in. card provides quick reference to frame size (182 to 445U) and book price for a-c motors from ¾ to 125 hp. Gives data for both dripproof and totally enclosed fan-cooled Tri-Clad 55 squirrel cage, horizontal motors. *General Electric Company.*

Circle number (130) on reply card.

Refrigerated storage facilities . . . for liquefied gases between +32 and —50 F . . . are explained in brochure which contains illustrations of vessels now in service and cutaway drawings of vessel types, with descriptions of refrigerating systems. *Chicago Bridge & Iron Company.*

Circle number (131) on reply card.

Shaftmounted geared speed reducers . . . are subject of Brochure F-2003, which contains illustrations, feature descriptions, and selection and ordering instructions. *U. S. Electrical Motors Inc.*

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Silastic wire and cable insulation . . . which withstands longtime exposure to severe environmental and operating conditions including heat, cold, moisture, weathering, corrosive fumes, ozone, corona, and nuclear radiation . . . is covered in new descriptive manual. *Dow Corning Corporation.*

Circle number (133) on reply card.

Stauffer Chemicals . . . Everywhere . . . booklet published in observance of company's 75th anniversary describes products manufactured and their applications. *Stauffer Chemical Company.*

Circle number (134) on reply card.

Technological and scientific developments . . . are reported in new quarterly publication entitled Engelhard Industries Technical Bulletin. Vol. I, No. 1 contains the articles "Catalysts for Acetylenes Removal From Gas Streams" and "Developments on High Temperature Thermocouples Using Noble Metals." *Engelhard Industries Technical Bulletin.*

Circle number (135) on reply card.

Temperature probes . . . 36 different aerodynamic, immersion, and surface temperature transducers are detailed in Catalog 66030. *Rosemount Engineering Company.*

Circle number (136) on reply card.

Top-entry thermoplastic ball valves . . . made of unplasticized polyvinyl chloride or Penton chlorinated polyether are subject of Bulletin TTP-180, "Ball Valves for Corrosive Service." *Tube Turns Plastics Inc.*

Circle number (137) on reply card.

Toxicological Reviews on Benzene, Toluene, and Xylene . . . second edition, prepared by Philip Drinker of the Harvard School of Public Health, is now available. 25 cents. *American Petroleum Institute.*

Circle number (138) on reply card.

Trinox thermocouple assemblies . . . are described in Bulletin TT-317, which provides complete technical information for the engineer for selection of the Trinox element, hot and cold junctions, process connection, and protective head. *Trinity Equipment Corporation.*

Circle number (139) on reply card.

Ultralite . . . glass fiber insulation for tanks . . . is explained in technical brochure. *Gustin-Bacon Manufacturing Company.*

Circle number (140) on reply card.

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Steel tanks for the handling, storage and transportation of gases, beverages, fuels, hydraulic fluids and other liquids. Stainless steel tanks for corrosive acids and gases.
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No. AJ832 ..... $99.50
G-1 TANK Stainless steel. Capacity 2100 cu. in. (9 gals.) 450 P.S.I. ¼" pipe thread port at each end. 24" long, 12" dia. Shipping weight 19 lbs. F.O.B. Chicago. (Two for $27.00.)
No. AJ63 Each $14.95
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D-2 AIR TANK Carbon steel. Capacity 500 cu. in. (approx. 2 gals.) 450 P.S.I. ½" pipe thread port at each end. 24" long, 6" dia. Postpaid. (Two for $8.50).
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CORNELIUS HIGH PRESSURE (1500-2000 P.S.I.) AIR COMPRESSOR Three cylinder, 3-stage compressor, complete with 27 volt, D.C. 20 amp. motor, with fan. Rated 1500 P.S.I. continuous duty, 2000 P.S.I. intermittent. Pressure switch in base. As released by Air Force, in used, serviceable condition. Covered by our 30 day GUARANTEE. 11½" long, 7" high, 9" wide. Shipping weight 12 lbs. F.O.B. Chicago. Limited quantity.
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PETRO/CHEM

news makers

▸ **Dr. Adalbert Farkas,** assistant director of research for Houdry Process Corporation, Philadelphia, has been elected president of the International Congress on Catalysis, Inc.

▸ **Herbert H. Olfe** has been named chief engineer of Tellepsen Petro-Chem Constructors, Houston.

▸ Recently promoted in the Odessa engineering department of El Paso Natural Gas Products Company were **John Wier,** to division mechanical engineer; **Ray Garrett,** to division chemical engineer, and **Mark Foerster,** to division electrical engineer.

▸ **Weldon R. Burns** has been appointed engineering manager of Badger Ltd., London, after completing his assignment as project manager of the Esso Rotterdam refinery recently constructed by Badger NV, The Hague.

▸ **Herbert C. Thober** is new manager of Sun Oil Company's Toledo, Ohio, refinery, replacing **John F. Harron,** appointed to Sun's advanced management and methods division with headquarters at Marcus Hook, Pennsylvania. **Koerner E. Leutz** replaces Thober as refinery superintendent at Toledo, and **John F. McKinney Jr.** succeeds Leutz as assistant superintendent.

▸ Standard Oil Company (Indiana) has named new managers at three refineries:

John H. Johnsen is new manager at Wood River, Illinois, succeeding **Louis H. Butterworth.**

Irvin C. Staeuble, formerly assistant manager at Sugar Creek, Missouri, succeeds **P. Craig Livesay** as manager there.

Norman T. Robey, who was assistant manager at the Whiting, Indiana, refinery, succeeds Johnsen as manager of the Neodesha, Kansas, refinery.

Butterworth and Livesay have been transferred to the manufacturing department general office in Chicago for special assignments.

▸ Key appointments at Shell Development Company are those of **A. J. Johnson** as vice president in the company's head office in New York and **T. W. Evans** to succeed Johnson as vice president and general manager of the Emeryville (California) Research Center. Johnson will take over responsibility of the company's licensing division as well as assisting in other executive functions.

▸ Sinclair Refining Company has appointed **Robert E. Howe** executive vice president and coordinator of petrochemicals and research and **R. M. Cooper** vice president and director and general manager of refineries.

▸ **Osgood V. Tracy** has been elected a director and an executive vice president of W. R. Grace & Co. Tracy, formerly president of Esso Standard division, Humble Oil & Refining Company, will be in charge of Grace's chemical business and will be

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EVERYBODY'S CHARGE STOCK

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The HOUDRIFLOW Process accepts in liquid or vapor form any fraction between naphtha and asphalt from both sweet and sour crudes. In the HOUDRESID Process, reduced crudes are converted into high octane gasoline and light distillate fuel—without production of heavy residual fuel.

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responsible for the seven operating divisions as well as the research division comprising the Grace Chemical Group.

▸ Appointments at the Bayway, New Jersey, refinery of Esso Standard division, Humble Oil & Refining Company:

Jim McGrory, assistant head, chemical products department.

Bill Ward, head, economics and design division, succeeding McGrory.

George Demakis, assistant division head.

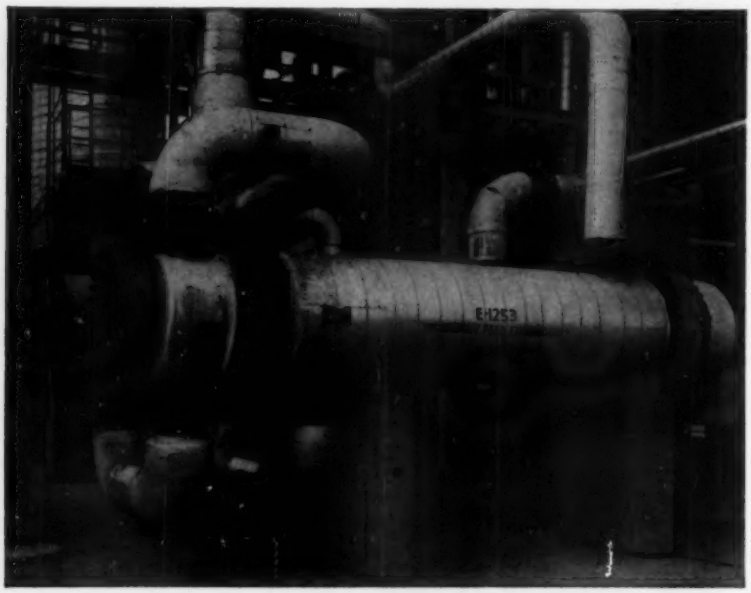
John Skvarla, group head, short range economics.

Carl Thorsten, senior engineer, technical department.

▸ **J. C. Weisinger** has been promoted to staff engineer in the petrochemicals section of technical division of the Baytown, Texas, refinery of Humble Oil and Refining Company.

▸ **D. F. M. McCormick** and **W. H. Tilley,** specialists in the research and development and technical service departments of Atlantic Refining Company, Philadelphia, have assumed new posts. McCormick is now with Industrial Raw Materials Corporation, New York, and Tilley is with DuPont in Philadelphia.

▸ **Thomas E. Workman** has joined the process engineering staff of Catalytic Construction Company, Philadelphia, his responsibilities will include planning of multiproduct petrochemical plants.



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Years of experience in engineering and fabricating of heat exchangers for the wide range of temperatures/pressures encountered in refining-petrochemical-natural gasoline plant processes enables EFCO to offer service-proved engineering design and guaranteed job-ratings.

This Shell Oil Company installation, in their Deer Park Refinery, is typical of the many high-pressure, high-temperature alloy exchangers designed and fabricated by EFCO, for platformer feed to effluent exchangers.

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guaranteed job-ratings
complete fabricating facilities
technical service before, during and after installation

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ENGINEERS AND FABRICATORS, INC.

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118

processing parade

Yuba Consolidated Industries, Inc., San Francisco, has acquired its third Tulsa company with the purchase of **Coynco Products, Inc.,** and has established a new subsidiary to be known as **Yuba-Tulsa Corp.**

K. W. Anderson Co. and **Arrow Industrial Manufacturing Co.** (AIMCO), previously purchased by Yuba, also will become part of Yuba-Tulsa.

The Coynco plant will be expanded and developed into a major manufacturing center for Yuba's shell and tube and air-cooled heat exchangers.

K. W. Anderson Co., manufacturer of high temperature furnaces for processing industries, is being consolidated with Yuba's Petro-Chem Development Division.

Walworth Company has formed a new lubricated plug valve division with sales and service headquarters at 3517 Polk Avenue, Houston. Clyde W. Cook has been appointed vice president in charge of operations of the new division.

The H. W. North Company, recently affiliated with the National-U. S. Radiator Division of Crane Co., has resumed independent operations as a designer and supplier of chemical process equipment and special-purpose machinery. New sales and engineering headquarters of the contracting and licensing organization are in New Cumberland, Pennsylvania.

Expanded facilities of **Oil Equipment Manufacturing Co.,** Louisville, Kentucky, include enlarged manufacturing, storage, and shipping departments. Offices, drafting, and engineering departments are now housed in a spacious 2-story, air conditioned building.

Appointments:

Wolverine Tube, Division, Calumet & Hecla, Inc., Carl T. Fuller, manager of special product sales, Allen Park, Michigan; L. A. Brewer, manager of sales administration, Allen Park; F. J. O'Donnell, sales representative, New York.

Universal Oil Products Company, Robert H. Carlton, product sales representative for the Midwest, operating from the Chicago area; Thomas M. McLoughlin, product sales representative for Eastern Seaboard states, operating out of Philadelphia.

Grove Valve and Regulator Company, Claude W. Brown, sales and technical service representative for Oklahoma and Kansas, headquarters in Oklahoma City.

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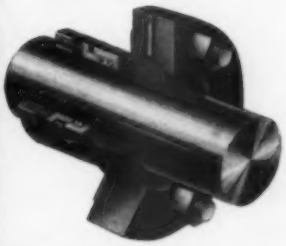
for
MONEY'S-WORTH
and
SERVICE-WORTH
specify



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- designs allow for maximum interchangeability of parts.
- backed by a national network of sales and service offices.
- standard parts stocked in Baton Rouge, La., Borger, and Houston, Texas, Kalamazoo, Los Angeles, Newark and St. Thomas, Ont.

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Refinery customers have found that, in comparison with other inhibitors, Dalpac 4 (Hercules 2,6-di-tert-butyl-p-cresol) saves up to three dollars on every thousand barrels of gasoline produced. Dalpac 4 inhibits gum formation, stabilizes gasoline color, and helps maintain engine cleanliness. Refiners have also found it to be excellent in turbine and transformer oils where it prevents deterioration, and does not affect electrical properties.

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Naval Stores Department
HERCULES POWDER COMPANY
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PIPE JOINT CLAMP STOPS LEAKS
at joint where pipe is screwed into fitting

SKINNER-SEAL
PIPE JOINT CLAMP stops leaks at joints where pipe is screwed into fitting. Any temperature—any pressure up to 2,000 pounds. Saves the cost of tearing out and renewing leaky fittings. Prevents shutdowns. In stock at most oil supply stores.

SKINNER-SEAL
EMERGENCY PIPE CLAMPS for safe, sure, lasting repair of splits and rust holes in pipe. No pressure too high. Anyone can apply in a few moments. Made in all sizes, ½" to 12," for steel and C.I. pipe. Stocked by practically all oil supply stores.

Complete line of Repair Clamps. Send for Catalog 54!

M. B. SKINNER CO.
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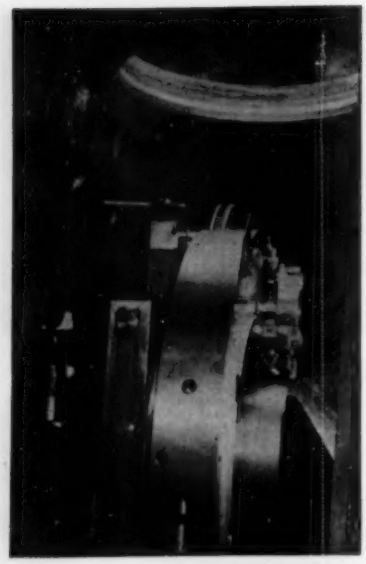

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Worn and damaged flywheel fits refinished in place.

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Most modern methods used in rebabbitting and machining engine and turbine bearings.

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Parade (Continued)

Bendix Computer Division, Delmer C. Davis, sales engineering staff, for Arkansas, Oklahoma, and part of Texas, based in Dallas.

Coppus Engineering Corporation, Werlla and Company, Houston, named exclusive district representative.

Oakite Products, Inc., J. Justin Basch, second vice president; William A. Baltzell, vice president; Harlis E. Martin, sales representative, Rock Island, Illinois; Charles W. Pearce, sales representative, Miami, Florida; Frank T. Mountjoy, sales representative, Kansas City, Missouri.

Rockwell Manufacturing Company, Harry W. Fisher, manager, central liquid meter products engineering, Pittsburgh, Pennsylvania.

Garlock, Inc., John E. Brennan, staff assistant to the president.

Fairbanks, Morse & Co., Alfred C. English, general manager, compressor division, Chicago.

New sales offices:

Carpenter Steel Co., at 3511 Hall Street, Dallas.

Bridgeport Brass Company, metals center at 1613 West 21st Street, Tulsa.

Ohio Steel Foundry Company, 724 South Los Angeles Street, Anaheim, California.

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A powerful blend of fast-acting solvents that literally "melt the rust away" —safe on all metals and alloys.

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Coarse screened. Medium screened. Fine screened. Extra fine grind. Which grade fits your needs?

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(Exploded View)

A Coal Tar TAPECOATing that Provides Single-Wrap Protection **PLUS** an Outer Wrap

- ★ It's more than just a coal tar coating!
- ★ It's designed for single-thickness application!
- ★ It has advanced features of uniformity!
- ★ It assures greater coverage!
- ★ It includes a tough outer wrapper!
- ★ It combines 20 years of manufacturing and field application experience!
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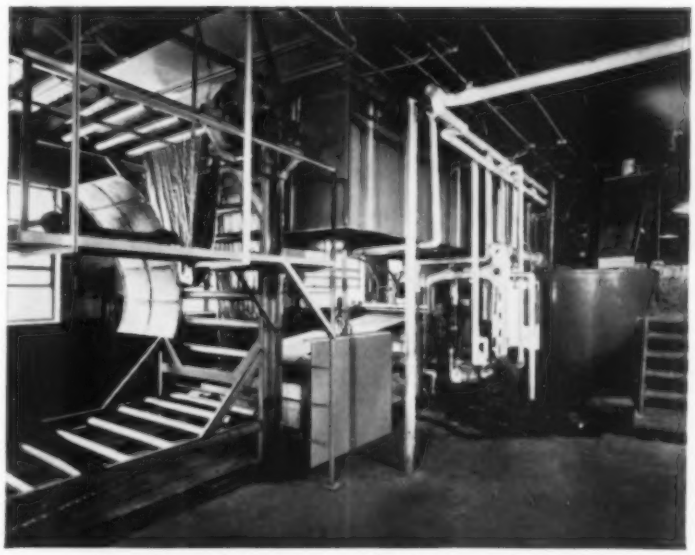

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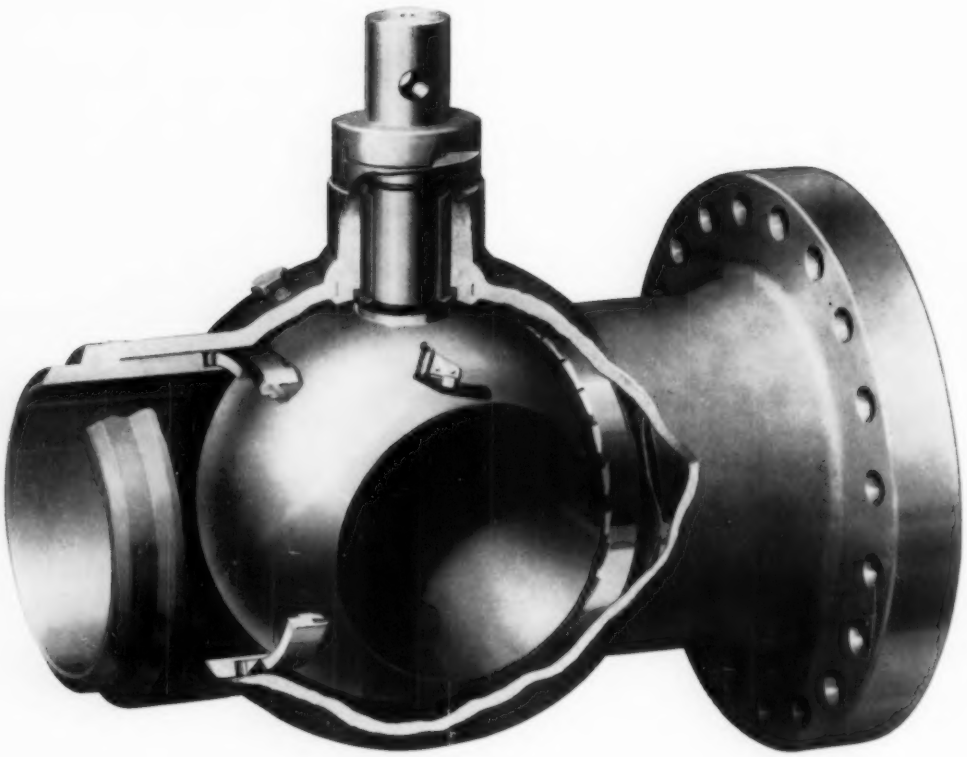

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with the Exclusive Rotating Seats

These valves handle the most abrasive and corrosive fluids—cannot freeze—cannot develop excessive body pressure; provide up-stream seating, double block and bleed, all with unbelievably easy operation.

They can be supplied in any material, size 2″ or larger to required working pressures and with any type or style of operator desired. The Cameron Ball Valves can be delivered from factories located in United States, Canada, Mexico, England and France.

CAMERON IRON WORKS, INC.—P. O. BOX 1212—HOUSTON, TEXAS

SHAPING THE FUTURE . . . *in Pipelining*

A DECISION WILL HAVE TO BE MADE by someone on whether a pipeline can be required to take gas under an expired contract at a higher rate. A somewhat complicated case involves Continental Oil Company and United Gas Pipe Line Company. Upon expiration of their contract, Continental asked FPC for authority to abandon and terminate the service, at the same time filing for an increase in its sale price. The higher rate was placed in effect subject to refund, but no action was taken on the abandonment application. Meanwhile UGPL refuses to take the gas, saying it is not worth the price asked, and Continental has taken the issue to court asking that United be forced to do so on the grounds that it cannot sell the gas elsewhere until FPC allows a termination of the service.

LIQUEFIED PETROLEUM GAS WILL BE EXPORTED from the Middle East in refrigerated form early in 1961. Aramco is constructing facilities at Ras Tanura for refrigerating and storing liquefied propane and butane, which are expected to be in operation next year.

RIGHTS-OF-WAY THROUGH INDIAN LANDS for oil and gas pipelines can now be granted for as long as 50 years, new government regulations making this possible. Maximum permissible term has been 20 years with a 20-year renewal. The new regulations do not automatically extend existing permits. New applications will be required in each case, which will be decided on individual merits. Consent of Indian landowners will be required as in the past.

INTRODUCTION OF WATER INTO CRUDE OIL pipelines to decrease pressure gradient is being given greater consideration and study. Although practiced in a small way for some years, recent investigations have been intensified, one by the Research Council of Alberta, Canada, who employed computers to advance the work. In a report made before the American Institute of Chemical Engineers, one of the important findings announced was that "maximum pressure gradient reduction factors ranged from 4 to 255 for the four oils tested and occurred at water contents of 60 to 70%."

AN "ULTRA-CENTRIFUGE" FOR MEASURING PROTECTIVE COATINGS has been built in Czechoslovakia. In a vacuum of the order of 10^{-7} mm Hg maintained in the centrifuge, a vertical rotor rotates at 6,000,000 rpm, at which speed adhesion strength even of galvanic coatings can be measured.

ENGINEERING NEWS

PRODUCT NEWS NATIONAL EDITION VOLUME NO. CI

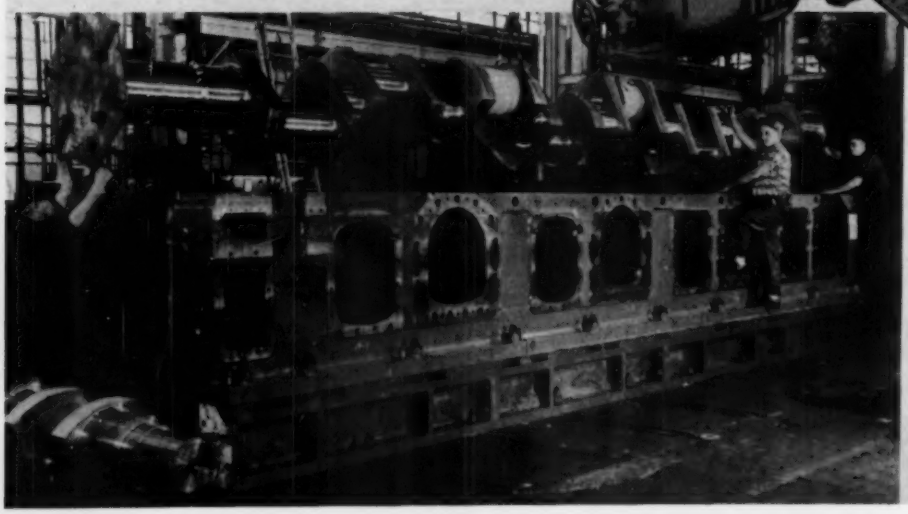
WORLD'S LARGEST!

CLARK INTRODUCES 5500 bhp V-TYPE GAS-ENGINE-COMPRESSOR—world's largest for pipeline gas transmission

Olean, New York—July 27, 1960—A new, high horsepower, V-Type Gas-Engine-Driven Compressor with compressor cylinders on one or both sides of the crankcase has been introduced by Clark Bros. Co., one of the Dresser Industries. Designated Model TCV, this turbocharged, 2-Cycle machine will be the world's largest gas-engine-driven compressor. Built in 12 and 16 power cylinder models rated at 4000 and 5500 bhp respectively, the TCV combines low fuel consumption with the known simplicity and dependability inherent in 2-Cycle design. Because fewer units of this size will be required for a given application, the compressor is designed to achieve substantial savings in capital investment and operating costs.

The use of compressor cylinders on one or both sides of the crankcase makes maximum use of available space and provides unprecedented cylinder flexibility for a wide range of operating conditions. The TCV-16 can be fitted with as many as eight large cylinders to handle [illegible] including stroke, power, side [illegible] der connecting rods, constant pressure jet assisted turbocharger. Features a husky 15½" crankshaft. The engine operates at unusually wide safe speeds, 180 to 300 rpm. The conservative 102 bmep rating is designed to assure low stress, long component life, high reliability and ample reserve capacity to handle temporary overloads.

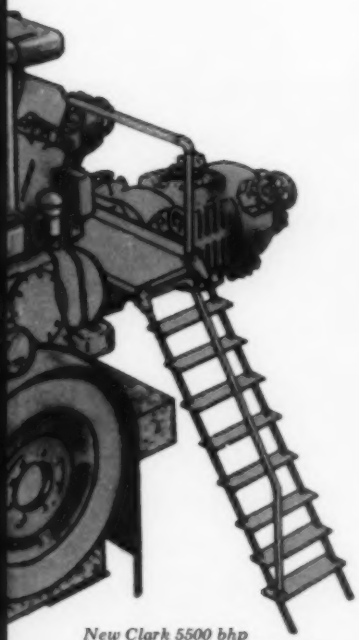
Clark 2-Cycle design requires substantially fewer parts than other type machines, hence there are less components subject to wear and replacement. Since every down stroke is a power stroke, there are twice as many power impulses over which to spread the load. As a result, the TCV is well suited to variable-speed, variable-load applications and performs smoothly at substantial speed reductions when torque is held constant.



Crankshaft being lowered into lower crankcase of new Clark Model TCV, 5500 bhp Gas-Engine-Driven Compressor. Note huge proportions of both case and shaft forging.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

SAVINGS IN CAPITAL INVESTMENT AND OPERATING COST OFFERED BY NEW CLARK 5500 bhp GAS-ENGINE-COMPRESSOR



New Clark 5500 bhp Model TCV-16, world's largest Gas-Engine-Compressor. Also available in 12 power cylinder Model TCV-12, delivering 4000 bhp.

Many features combine in the new Clark TCV-16 Gas-Engine-Driven Compressor – world's largest integral unit – to help reduce investment and operating costs of pipeline gas transmission. Available in 12 and 16 power cylinder models, the TCV design offers these cost-cutting advantages:

- Highest horsepower – fewer units required
- 2-cycle simplicity – maximum dependability
- Pure turbocharging – bonus power and best overall fuel economy
- Wide, safe speed range – 180-300 rpm at constant torque
- Low bmep – long life and high overload capacity
- Less costly to automate – fewer units, fewer controls

The TCV-16 can accommodate as many as eight *large* compressor cylinders and still provide easy accessibility. Maximum use of space and unprecedented flexibility to meet a wide range of operating conditions are assured by the new design, in which compressor cylinders can be located on one or both sides of the crankcase. These units can handle all types of pipeline and process requirements including multi-service applications where several gas streams are compressed by one machine. Major economies result from the use of fewer, more powerful units for a given application.

Many features of the new Clark TCV Gas-Engine-Driven Compressors have been thoroughly proved in Clark TLA Compressors and in the Clark TPV Gas Engines. Find out how these savings can be yours – what the TCV-12 and TCV-16 mean to you in terms of profit. Consult your Clark representative or write today for Bulletin No. 188.

CLARK BROS. CO., OLEAN, N.Y.

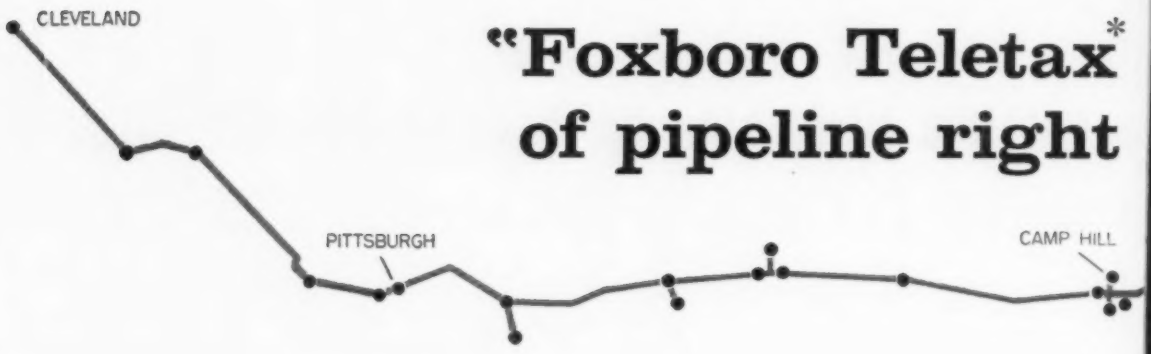
CLARK®

DRESSER INDUSTRIES INC.
OIL • GAS • CHEMICAL
ELECTRONIC • INDUSTRIAL

ENGINES ■ GAS TURBINES ■ COMPRESSORS

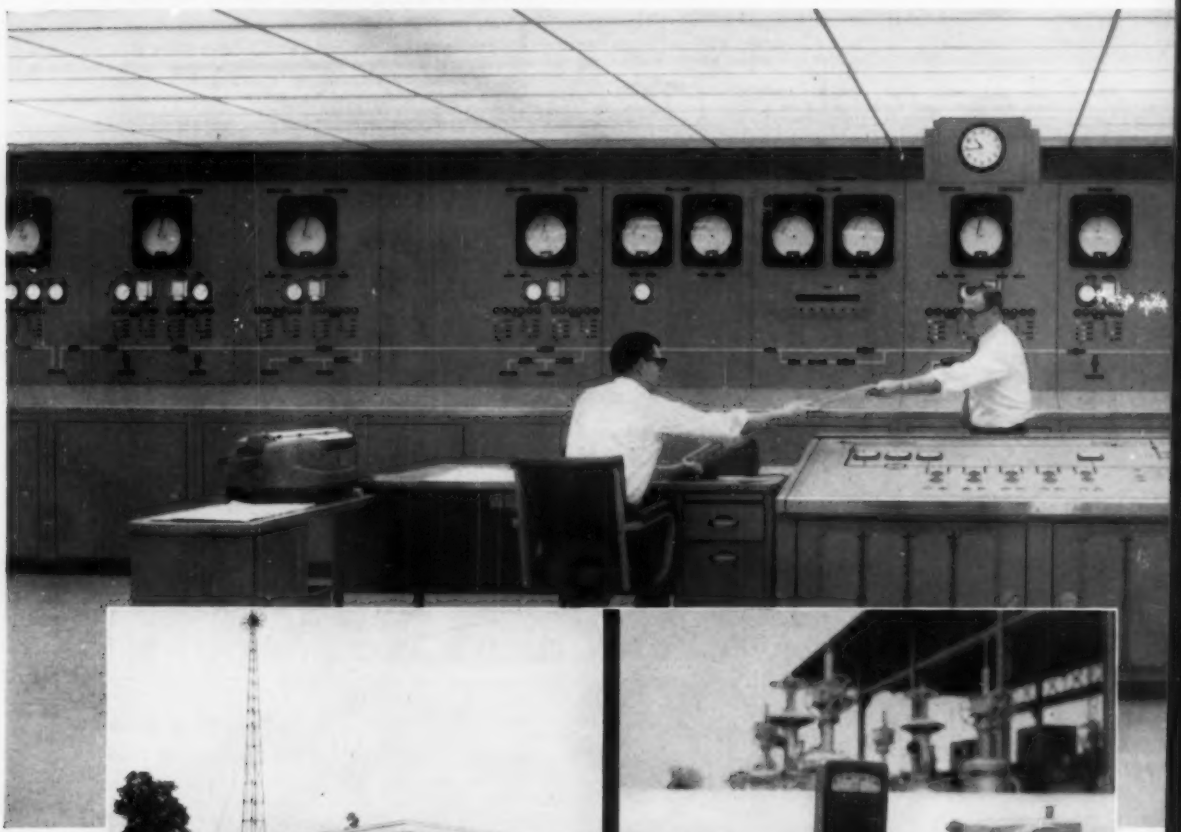
FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Laurel Pipe Line Company reports:



"Foxboro Teletax* of pipeline right

447-mile Laurel Pipe Line Company is owned by the Gulf Oil Company, the Sinclair Pipe Line Company, and Texaco, Inc. Line serves 22 terminals between Philadelphia and Cleveland—has a capacity of 160,000 bpd.



Central dispatching station at Camp Hill, Pa., is linked by microwave to the 62 Foxboro Teletax transmitters located along the 447-mile Laurel pipeline.

Foxboro M/44 pressure transmitter, sends signal to pumping station control room at rear while Teletax transmitter (in explosion-proof housing) beams pressure signal back to Camp Hill.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Telemetering puts 447 miles at our fingertips"

Deliveries to 22 terminals controlled from central dispatching station.

Foxboro Teletax Receivers on dispatchers' panel in Camp Hill, Pa., show 58 pressure and flow signals from pumping and metering stations along the line. Flow signals also go to totalizers on the boards, as well as to data logger next to dispatchers' desk.

PHOTOGRAPHY BY JOHN H. TROUP, JR., HARRISBURG

Picture a 24" to 14" pipeline starting in Philadelphia and ending in Cleveland, 447 miles away. Then picture 16 different petroleum products, belonging to 3 different oil companies, flowing to 22 delivery points. Picture this, and you understand the complexity of the Laurel pipeline.

To help Laurel dispatchers with their complex scheduling task, 62 Foxboro Teletax Telemetering Systems are employed. Transmitters are located at pumping and metering stations up and down the line; receivers at a central dispatching station in Camp Hill, Pennsylvania. Transmission is by company-owned microwave, supplemented at some locations by leased line circuits.

"Reliability was one of the chief concerns when installing our telemetering equipment," Laurel reports. "A high degree of reliability would allow us to adhere to predetermined delivery schedules — save pumping and manpower costs. In short, help operate the line more efficiently. And, with our Teletax systems, we've been getting that reliability."

Foxboro Teletax Telemetering systems are noted for their simplicity, their high sustained accuracy, as well as their reliability. They can be used with the most advanced transmission techniques. Write for Bulletin 17-11 — it gives all the details. The Foxboro Company, 3810 Norfolk Street, Foxboro, Massachusetts.

*Reg. U.S. Pat. Off.

FOXBORO

REG. U. S. PAT. OFF.

DEWTECTOR

Gives positive dew point reading under all conditions.

CHART AVERAGER

Continuously averages temperature, gravity or pressure charts automatically.

NEW!

from UGC INSTRUMENTS

United Gas Corporation — the world's largest handler of natural gas — stays ahead in research and instrument development through its newly organized UGC INSTRUMENTS Division. Research has been the key to many UGC operating problems: *safety, dependability, accuracy, economy* and *speed.* Whatever the problems in the utilities industry... gas, electric or water... UGC INSTRUMENTS is solving these problems with instruments that have been developed through research.

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Shreveport, Louisiana
Phone UN 1-4531 — LD 81

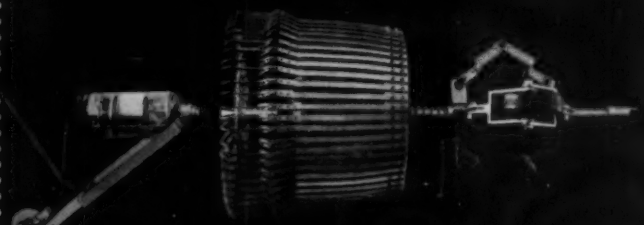
UGC INSTRUMENTS
A DIVISION OF UNITED GAS CORP.

METERCORDER

First portable digital tape recorder for meter reading. Completely automatic and weatherproof.

VIGILANT

Assures safe, continuous heater operation on pipelines and producing equipment.

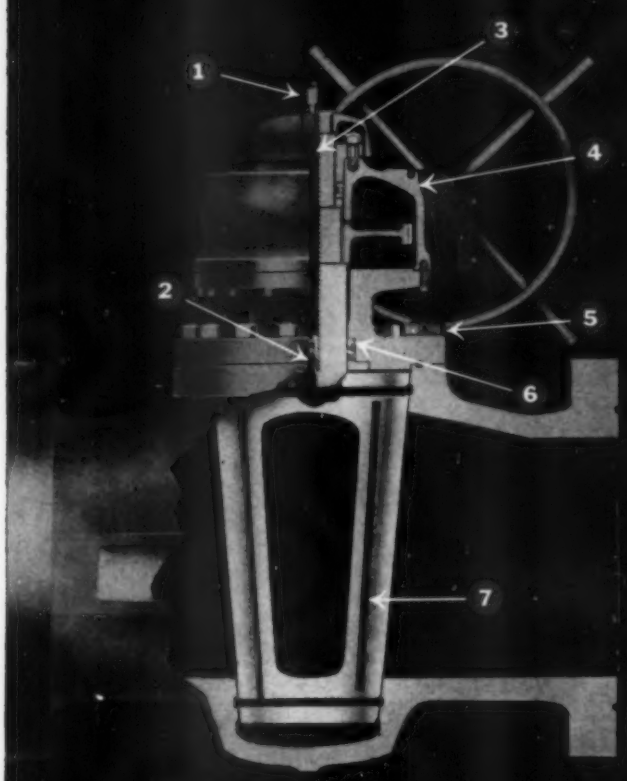


CORROSION DETECTOR

Locates, measures and records internal pipe corrosion.

See these and other instruments developed by United Gas Corporation at the AGA Convention.

7 characteristics that make WALWORTH a better Lubricated Plug Valve



1. Valve can be lubricated with a Walworth High Pressure Lubricant Gun without removing lubricant fitting.

2. Double ball check valve prevents line pressure from getting into lubricant system.

3. Groove, cut part way up side of lubricating fitting, provides extra safety feature by allowing operator to note any tendency of lubricant to blow out **before** fitting is entirely removed.

4. For buried pipelines—gear housing design permits simple attachment of lubrication and handwheel extensions without modifying the gearcase.

5. Standard bolt threads, rather than fine threads, means easy replacement of nuts and bolts from local stocks.

6. Two overlapping Teflon* packing rings form an effective seal against possible leakage without "grabbing" the plug shank. Low break-out torque—plug turns easier.

7. Vertical and circumferential lubricant grooves completely frame the port openings, assuring a tight seal against leaks.

*Du Pont registered trade-mark

Cutaway of a 24-inch Walworth Lubricated Plug Valve

you always know that a WALWORTH LUBRICATED PLUG VALVE will operate

No matter when you need it, you can count on a Walworth LPV to operate easily and dependably in handling gas, crude or finished products. In petroleum service throughout the world, these valves have long proved their complete dependability and easy maintenance. Walworth also designs and manufactures Gate, Globe, Angle and Check Valves for the oil and gas industries. For information, write Walworth Company, Lubricated Plug Valve Division, 3517 Polk Avenue, Houston 23, Texas.

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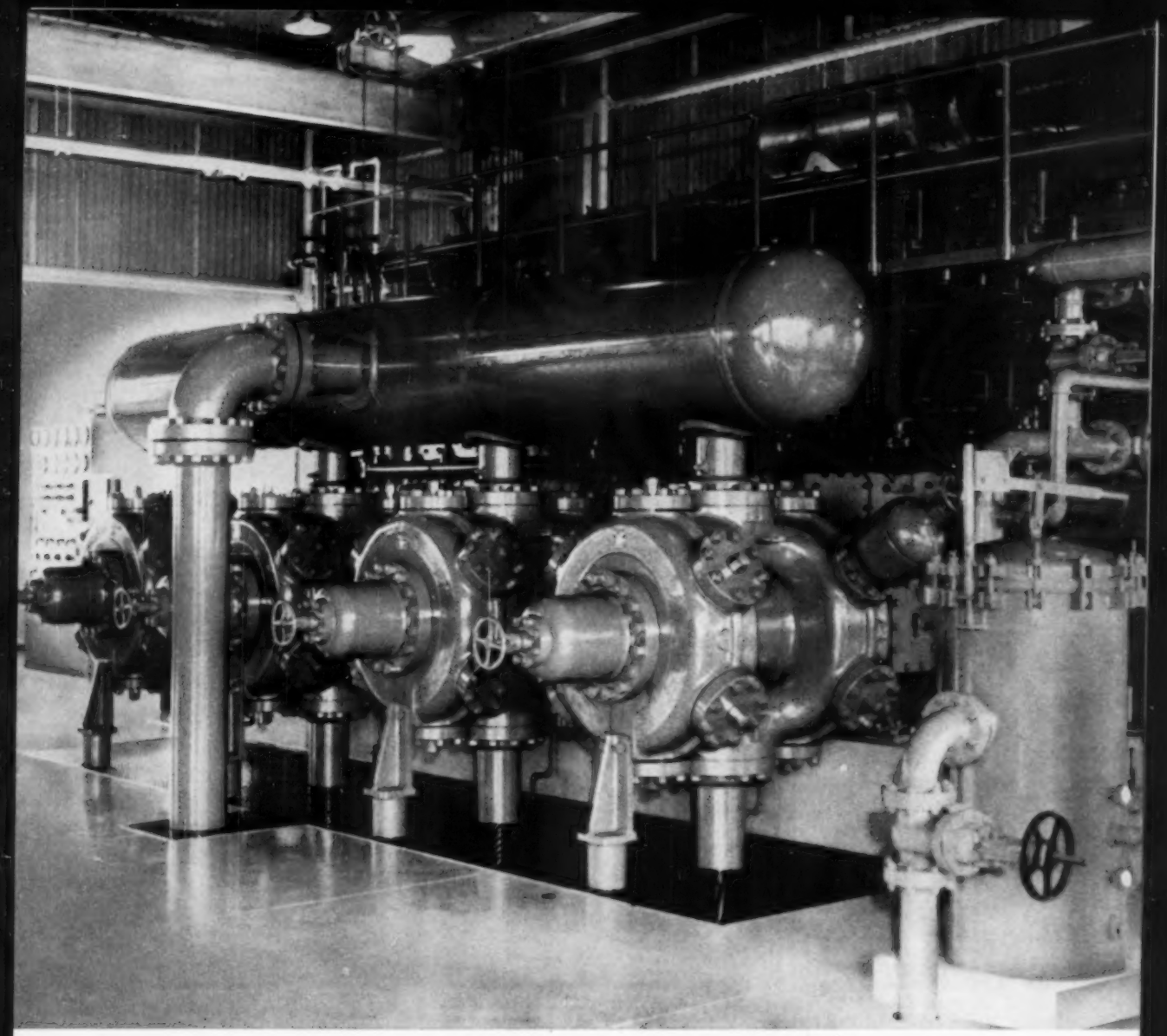
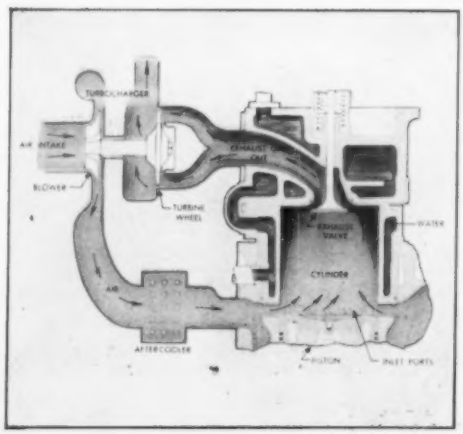
DISTRIBUTORS IN PRINCIPAL CENTERS THROUGHOUT THE WORLD

WALWORTH SUBSIDIARIES: ALLOY STEEL PRODUCTS CO. • CONOFLOW CORPORATION • GROVE VALVE AND REGULATOR CO. M&H VALVE & FITTINGS CO. • SOUTHWEST FABRICATING & WELDING CO., INC. • WALWORTH COMPANY OF CANADA, LTD.



At Northern Natural's Clifton Station, this SUTC engine compressor operates

20 HOURS A DAY...FOR 3 STRAIGHT YEARS



Self-sustained turbocharging at any speed and load is possible because of SUTC's exclusive Uniflo scavenging.

Five years ago a remarkable new engine compressor was introduced.

Called the SUTC, this Worthington turbocharged 2-cycle engine compressor was unlike any other. Combustion air enters thru side inlet ports, *but the exhaust is thru overhead valves.* Valve timing can be arranged to give maximum supercharging effect.

On paper, straight-thru or "Uniflo" scavenging has many advantages. The turbocharger operates over the entire speed and load range without help from external sources. Scavenging efficiency is increased and pulsations practically eliminated.

Now came the real test. More than 130,000 hp were installed. Operators praised the SUTC's exceptionally smooth, quiet operation. Operational records confirm the machines reliability. Unit G-2312 is typical. This 8 cylinder, 2000 hp SUTC engine compressor was installed in 1957 in Northern Natural Gas Company's Clifton, Kansas Station. To date, it has logged over 20,000 hours—an average of more than 20 hours a day for 3 straight years. A sister unit installed last year has equalled this performance.

May we send you complete data on this unique engine compressor? Please write to H. C. Barten, Worthington Corporation, P.O. Box 953, Buffalo 5, N.Y.

WORTHINGTON

Armco Line Pipe Combines Strength and Economy

New steels are born at Armco

Low residual stresses in line pipe mean more strength to handle unforeseen or accidental overloads. Tests show that the maximum residual stress in Armco Pipe is about 90 per cent less than in many commonly used standard pipes.

It's thrifty to specify Armco Line Pipe, too. You don't pay for "extra" steel—132 different diameter-wall thickness combinations let you meet your requirements *exactly*.

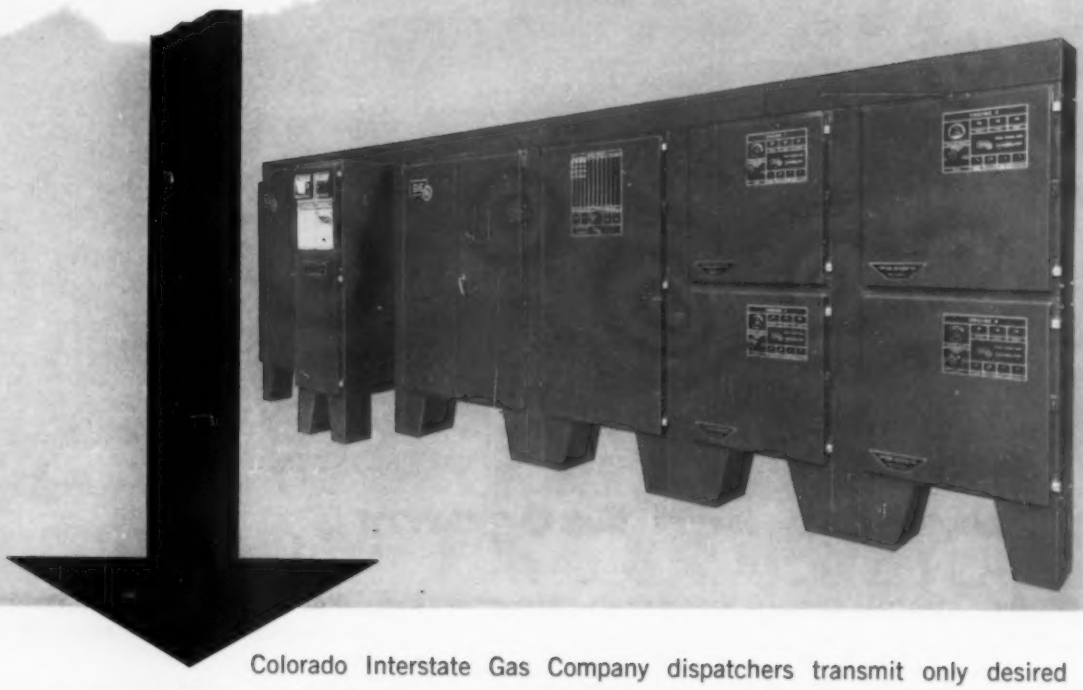
Write us for complete information on Armco Line Pipe. Armco Drainage & Metal Products, Inc., 5010 Curtis Street, Middletown, Ohio.

ARMCO DRAINAGE & METAL PRODUCTS

Subsidiary of ARMCO STEEL CORPORATION

OTHER SUBSIDIARIES AND DIVISIONS: Armco Division • Sheffield Division • The National Supply Company • The Armco International Corporation • Union Wire Rope Corporation

why CIG supervises remotely, automates locally



Colorado Interstate Gas Company dispatchers transmit only desired discharge pressure settings; automation at each compressor station responds by maintaining the selected value for optimum system economy. ■ If communication links fail, local automation operates without interruption. Log-Alarm units insure station safety. Dispatchers are alerted only when trouble occurs. ■ Solid-state components assure maximum reliability. "Building-block" design allows SIE to fit your needs exactly. ■ Accelerate your operating cost reduction program by writing: **SOUTHWESTERN INDUSTRIAL ELECTRONICS**

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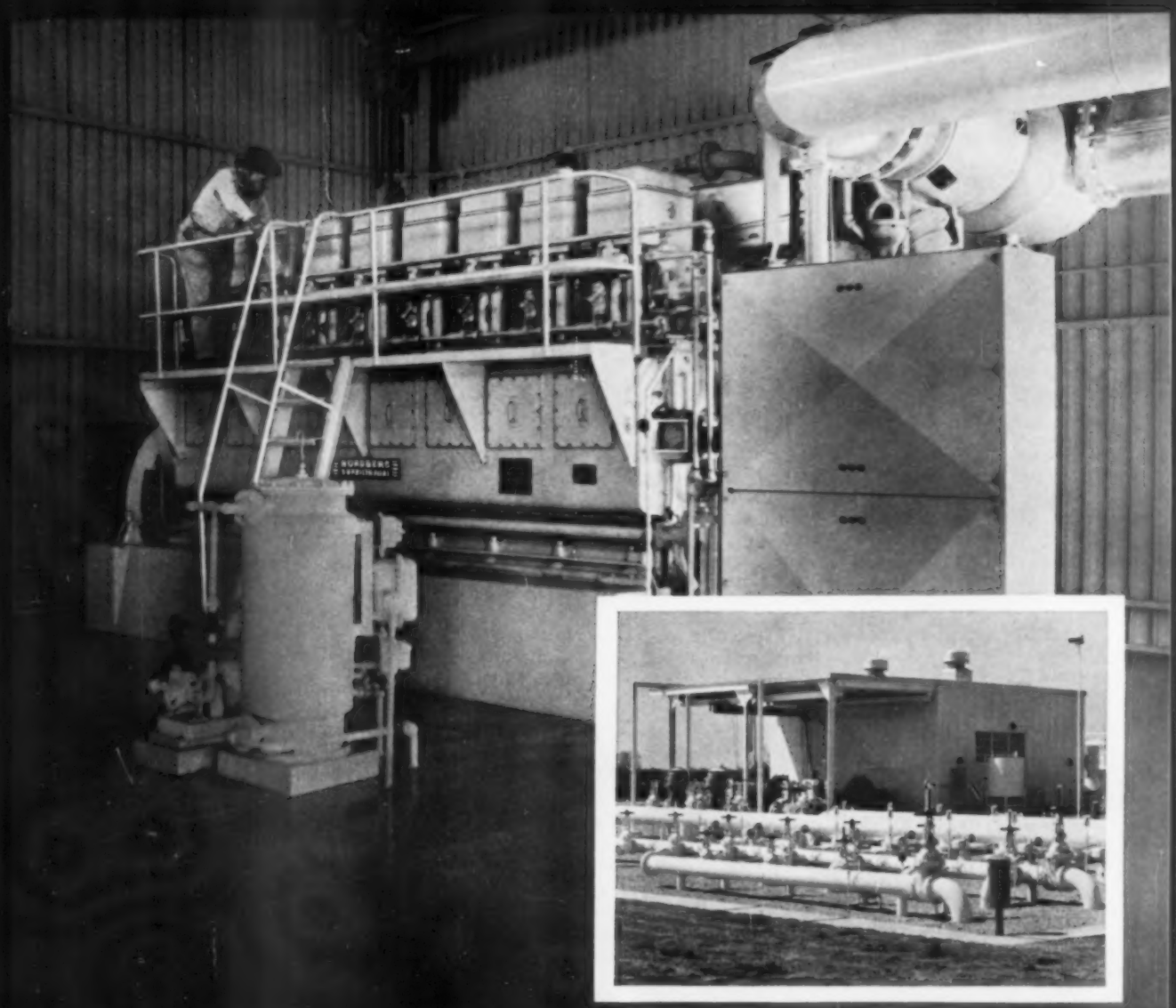
Division of Dresser Industries, Inc.

SIE



Pipe line engines by Nordberg

One of two Nordberg 2000 hp dual fuel engines powering main line pumps at the Teague, Texas station of Sinclair Pipe Line Co. All mechanical equipment is lease-rented from Nordberg. Note that building houses only the engines. Pumps, gears, and most auxiliaries are outside.

© 1960, N. M. CO. O-160

NORDBERG MANUFACTURING COMPANY
MILWAUKEE 1, WISCONSIN

ATLANTA • CLEVELAND • DALLAS • DULUTH • HOUSTON • KANSAS CITY • MINNEAPOLIS
NEW ORLEANS • NEW YORK • ST. LOUIS • SAN FRANCISCO • TAMPA
WASHINGTON • TORONTO • VANCOUVER • JOHANNESBURG • LONDON • MEXICO D. F.

Proved on the spread:

THE GAR WOOD-BUCKEYE 318 PIPELINER

gives you more production than any other pipeline ditcher

This big, fast pipeline ditcher speeds up *any* pipeline job—handles it easier and at lower cost than any other ditcher ever built. That's because the 318 has dozens of exclusive ditcher features built in to boost production up 20% each day, give you more ditch per gallon of fuel. Check these modern ditcher features—standard equipment on the 318:

Torqmatic Converter Drive delivers the required torque *automatically*, even when the work load varies as much as 40%. No changing gears, no throttle adjustments necessary. Tail shaft governor maintains constant output shaft speed.

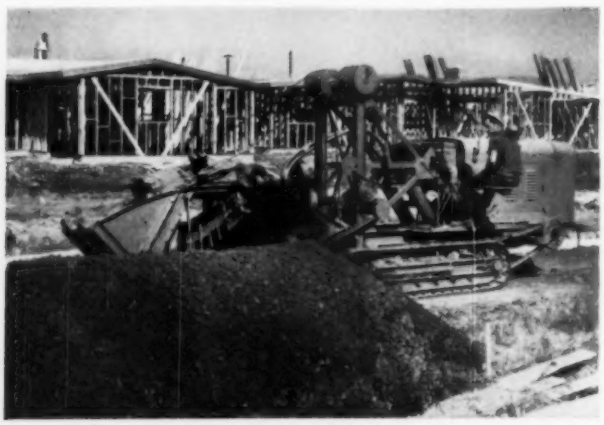
Dual-Drive Hydraulic Conveyor handles any volume of spoil. Independent of all other operations.

Hydraulic Digging Wheel Hoist allows on-the-go adjustments for depth and grade . . . also completely independent.

Modern Power Train is designed specifically for heavy-duty pipeline service. Split-shaft output drive provides independent wheel and traction speeds. Exclusive Hi-Lo traction shift lets you change digging speed 50% without disengaging main engine clutch.

You can transport the 318 on a standard low boy. You can service it quickly and easily. Why settle for less than the most modern, the most efficient, the most economical pipeline ditcher you can buy? See your Gar Wood-Buckeye dealer.

Other Gar Wood equipment . . . *performance-proved for pipeliners*



GAR WOOD-BUCKEYE DITCHERS—the widest range of ladder and wheel type ditchers in the industry for clean, accurate and fast digging of transmission, gathering and distribution lines. Only Gar Wood-Buckeye gives you so many "extras" as standard equipment.

GAR WOOD TRACTOR EQUIPMENT—matched to rugged Euclid tractors—designed to handle the toughest pioneering, backfilling and cleanup assignments. Line includes front- and rear-mounted cable control units, Tipdozers, Dozecasters and Rippers.

GAR WOOD TRENCH HOE—a rugged ¾ yard machine—designed for high-production excavating and material handling. Independent travel lets operator hoist or swing while moving. Built-in chain crowd puts full engine power into every bite, simplifies conversion.

GarWood
INDUSTRIES, INC.
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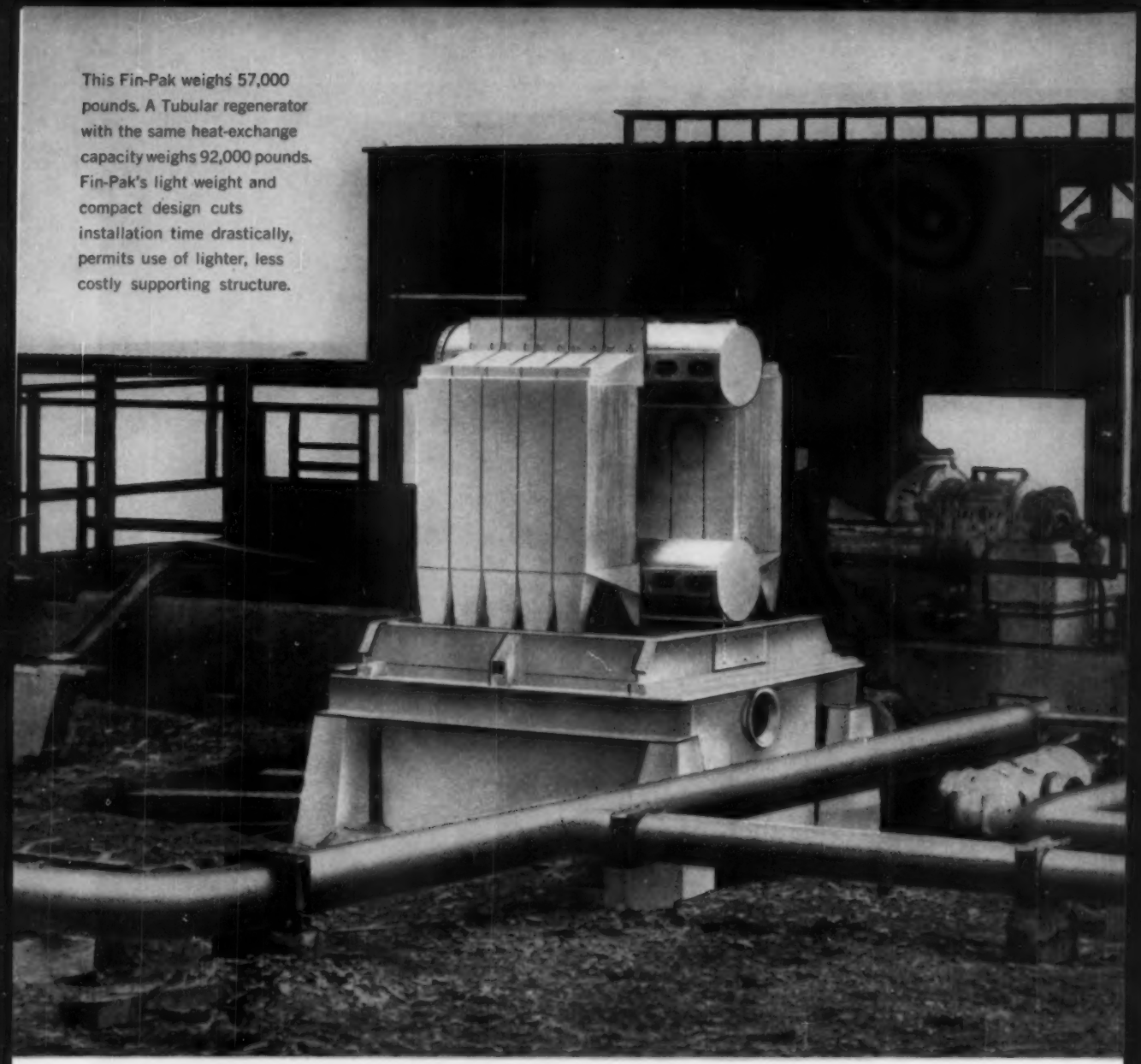

This Fin-Pak weighs 57,000 pounds. A Tubular regenerator with the same heat-exchange capacity weighs 92,000 pounds. Fin-Pak's light weight and compact design cuts installation time drastically, permits use of lighter, less costly supporting structure.

MOST EFFICIENT HEAT RECOVERY UNIT FOR GAS TURBINES ALSO EASIEST-TO-INSTALL: **FIN-PAK**®

If easy installation is one of the big reasons you chose gas turbines for compressor station power, Fin-Pak is good news. Fin-Pak can be installed completely in less than 500 man-hours*—less time than it takes to install a tubular heat exchanger of the same capacity. That's because the Fin-Pak is only half the size of a tubular regenerator of equal capacity, and weighs only half as much.

Fin-Pak cuts fuel bills 30%, too.** What you save on fuel can write off the cost of the Fin-Pak within two years. And a Fin-Pak needs almost no maintenance except for an occasional cleaning with compressed air.

All these advantages add up to the fact that nothing can move so much gas so economically as a gas turbine equipped with a Fin-Pak. For more information about the Fin-Pak, including actual performance records of units now in operation, call or write The Air Preheater Corporation.

**On a 5,000-hp gas turbine.*
***An 80% effective Fin-Pak in a gas turbine cycle at 6 to 1 pressure ratio and a turbine inlet temperature of 1,500°F can reduce fuel consumption by more than 30%.*

THE AIR PREHEATER CORPORATION

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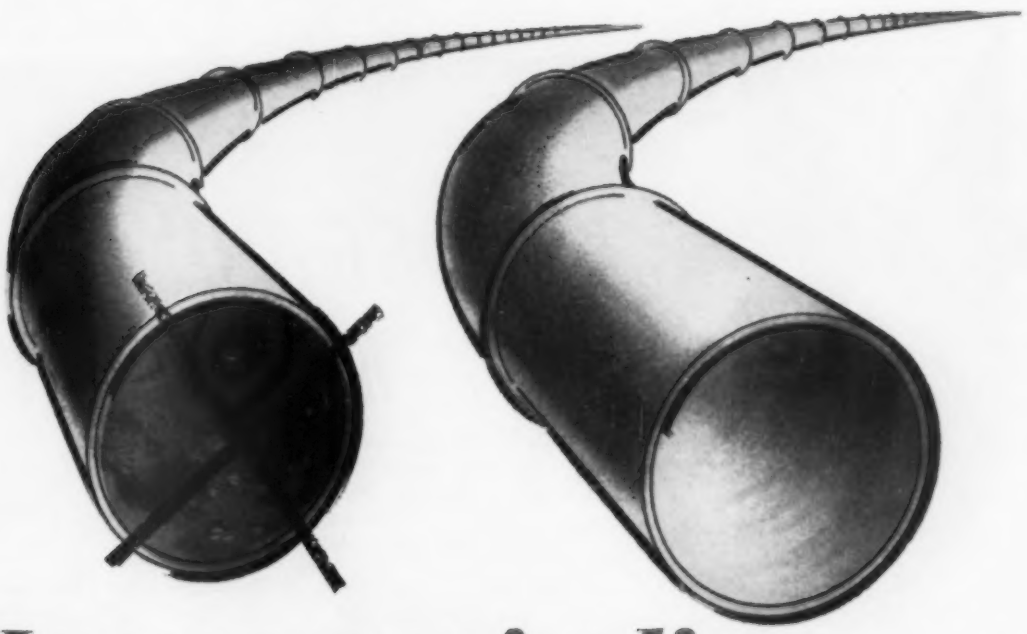

Keep your pipeline corrosion-free with Solvay Sodium Nitrite

To prevent corrosion right from the start, add Solvay® Sodium Nitrite in low, economical concentration to the products you're moving when you open a *new* pipeline. (Your pipe stays as clean as the cross-section on the right!) You can also use it effectively on older, now-in-service lines—to arrest corrosion and prevent further internal damage.

Solvay Sodium Nitrite forms an invisible gamma oxide film that protects the inner pipe surface from attack by occluded water. It is readily injected by a proportioning-type pump operated by the fluid that is being pumped.

Solvay Sodium Nitrite has several important advantages over other inhibitors. It costs less than most organic compounds. Being soluble in water and insoluble in petroleum products, relatively small amounts are needed. It will not contaminate these products. It will not react with most impurities or organic inhibitors in other petroleum products that may be in the same line.

For more facts and a test sample, mail the coupon now to Solvay.

Sodium Nitrite • Caustic Soda • Calcium Chloride • Chlorine • Chloroform
Caustic Potash • Potassium Carbonate • Sodium Bicarbonate • Soda Ash
Ammonium Chloride • Methyl Chloride • Ammonium Bicarbonate • Vinyl
Chloride • Methylene Chloride • Cleaning Compounds • Hydrogen Peroxide
Aluminum Chloride • Mutual® Chromium Chemicals • Snowflake® Crystals
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☐ A. Test sample of Solvay Sodium Nitrite

☐ B. Booklet—"Sodium Nitrite for Rust and Corrosion Prevention"

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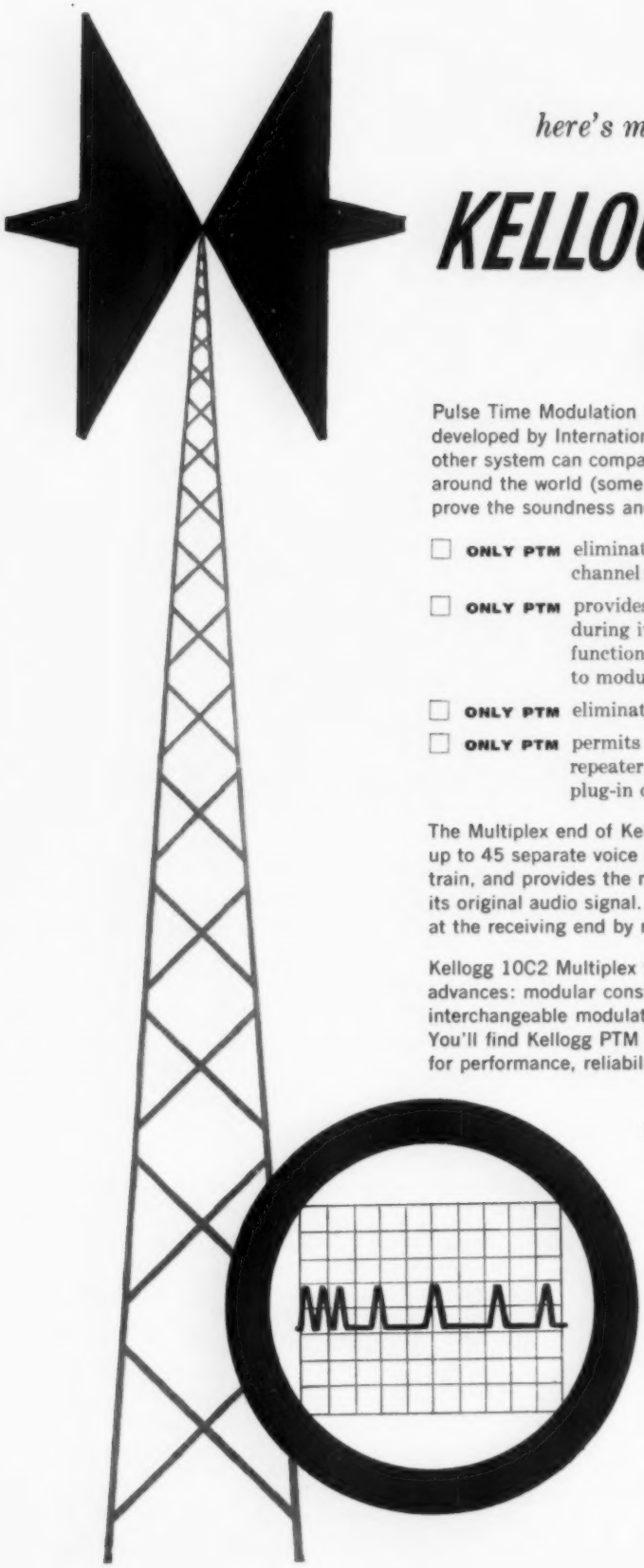


here's microwave at its simplest and best!

KELLOGG 10C2 PTM MICROWAVE

Pulse Time Modulation is the foolproof microwave pioneered and developed by International Telephone and Telegraph Corporation. No other system can compare with it in simplicity and reliability. Installations around the world (some dating back to ITT's early systems in the '30's) prove the soundness and reliability of PTM.

- ☐ **ONLY PTM** eliminates complicated tuning or filtering for voice channel separation. All demodulators are interchangeable.
- ☐ **ONLY PTM** provides separate and distinct channels, open only during its own time interval. Therefore S/N is not a function of channel loading; each channel is insensitive to modulation on the other channels.
- ☐ **ONLY PTM** eliminates frequency displacement over the voice channels.
- ☐ **ONLY PTM** permits *any number* of channels to be dropped at a repeater station. Only one additional modulator and one plug-in demodulator are required to drop each channel.

The Multiplex end of Kellogg 10C2 Microwave system can combine up to 45 separate voice frequency channels into a Time-Modulated Pulse train, and provides the means for restoring each of the channels into its original audio signal. Each signal is sorted into its proper channel at the receiving end by means of the distinctive marker pulse it carries.

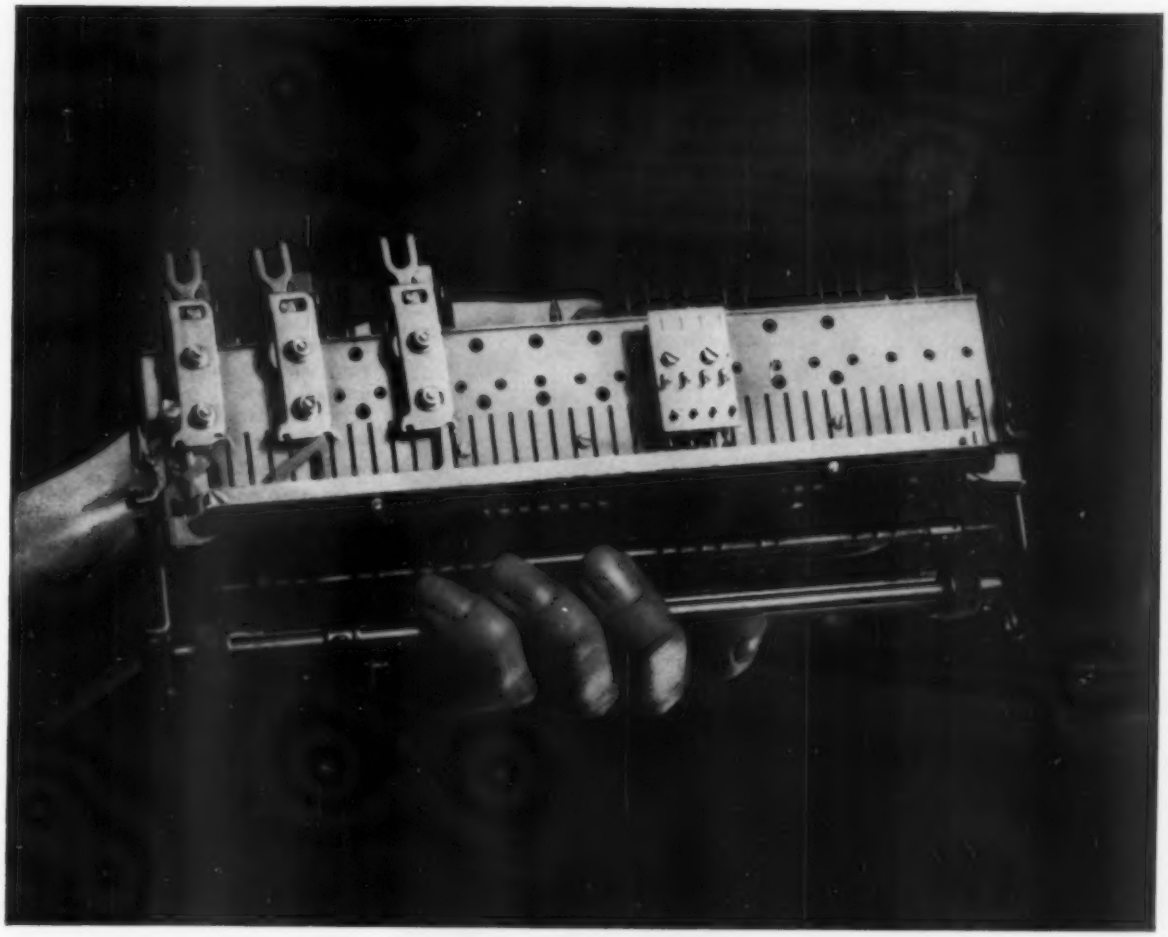
Kellogg 10C2 Multiplex features the latest and most efficient engineering advances: modular construction, printed circuitry, plug-in channel units, interchangeable modulators and demodulators, and many others. You'll find Kellogg PTM Microwave meets your highest specifications for performance, reliability and engineering design.

Complete technical details will be sent on request. Write to Kellogg's Microwave Division, Box 2725, Raleigh, North Carolina.

KELLOGG Communications Division of ITT CHICAGO, ILLINOIS

Kellogg Switchboard and Supply Company, 6650 South Cicero Avenue, Chicago 38, Ill. Communications Division of International Telephone and Telegraph Corporation

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD



Stunt Box—your Big Plus with Teletype printers

Built into Teletype Model 28 page printers is a control device called the Stunt Box. The function of this unique component is to provide extra control facilities for both local and remote operations. Thus—in addition to transmitting, receiving and recording messages and data—the page printer can be used for a variety of switching, remote control and selective calling tasks.

The Stunt Box reduces costs by simplifying equipment needs and systems arrangements. It is the Big Plus—the extra value in Teletype Model 28 page printers and automatic send-receive sets.

Teletype Corporation manufactures this equipment for the Bell System and others who require the finest in data communications equipment.

Write for free 20-page brochure, "The Teletype 28 Stunt Box," to Teletype Corporation, Dept. 92K, 5555 Touhy Avenue, Skokie, Illinois.

Typing Tape Punch

Tape Reader

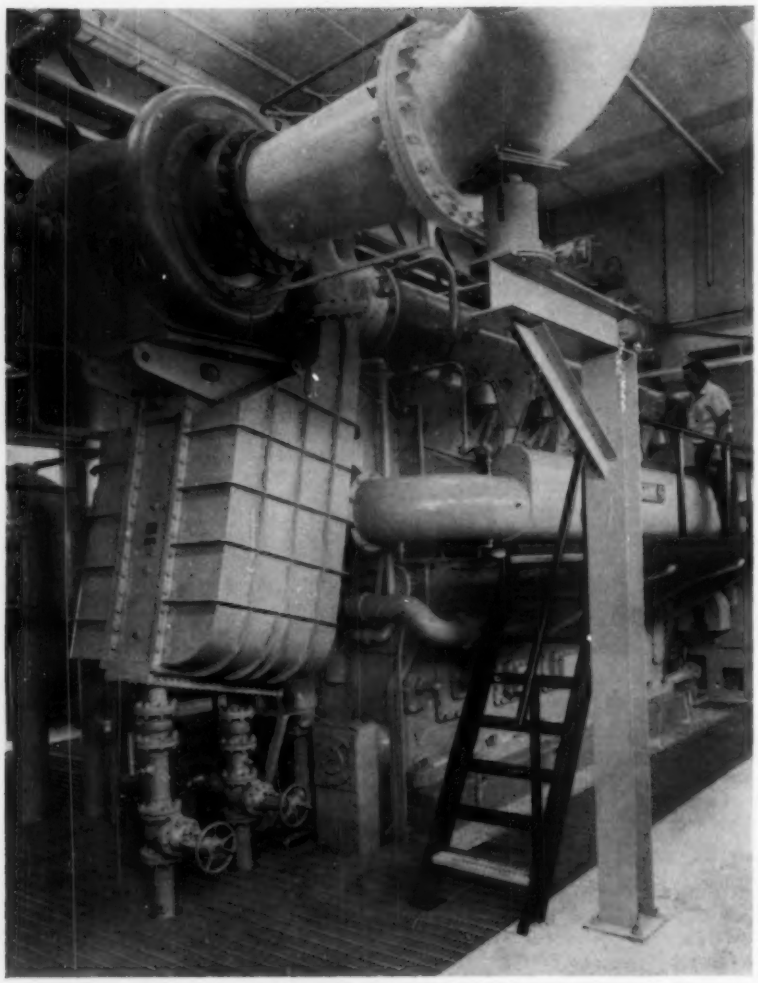
Send-Receive Page Printer

Automatic Send-Receive Set

TELETYPE®
CORPORATION
SUBSIDIARY OF *Western Electric Company* INC.

Two-cycle engine proves itself

Unique pumping unit on gas transmission system lives up to design requirements in 1500-hour operating test



The 2-cycle gas engine driving a centrifugal compressor is gas transmission industry's first combination of this kind.

IN DECEMBER 1959, Clark Bros. Co. and Columbia Gulf Transmission Company entered into an agreement to install a Clark TPV-10 2-cycle engine-driven centrifugal compressor to determine the economics and feasibility of the installation with regard to:

- The merits of a 2-cycle engine driving a centrifugal compressor compared to a 4-cycle engine driving a centrifugal compressor, and
- Operation of a non-attended 2-cycle engine-driven centrifugal compressor running in conjunction with existing engine-driven reciprocating compressors at a common compressor station site.

The general layout and engineering design philosophy was developed jointly by Columbia Gulf Transmission Company, Clark Bros. Co., and Gulf Interstate Company. Detailed design and engineering of the station was performed by Gulf Interstate Company beginning in January 1959. The station automatic control equipment was designed by Columbia Gulf. The construction contract was awarded to Mid-Valley Utility Constructors in mid-1959, the engine placed in service on June 1960.

A minimum of operational difficulties were experienced in the initial start-up of this station reflecting the correctness of basic design and the high quality of workmanship.

Minimum Cost of Service

The basic design concept is one of low cost of service consistent with maximum availability and dependability.

Late in August, Columbia Gulf Transmission Company and Clark Bros. Co. demonstrated to representatives of leading gas transmission and engineering companies, and the trade press, a new type of gas pumping unit installed at Hampshire, Tennessee. This was the natural gas pipeline industry's first teaming of a 2-cycle, V-type gas engine and a centrifugal compressor. It represented several other "firsts" as well:

First of a series of extremely large Clark 2-cycle engines . . . the initial unit, a 10-cylinder engine rated at 4000 bhp will be followed by 12 and 16-cylinder machines rated at 4800 and 6400 bhp, respectively.

First application of the Clark centrifugal compressor with an engine driver . . . it has been in use for nine years with gas turbine and electric motor drivers.

First use of a gear of this transfiguration in natural gas transmission . . . it has had long previous use in ships and locomotives.

At the time of the demonstration the unit had been in operation for approximately 1500 hours. Engineering details of the installation and performance data are given in the accompanying article. *—Editor's Note*

as variable speed prime mover

Corder Reynolds, *Project Engineer, Columbia Gulf Transmission Company*

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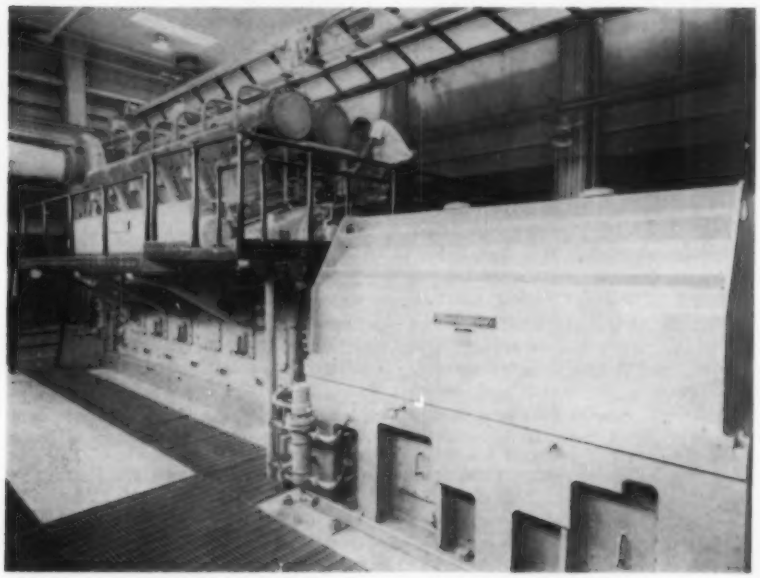


Speed increasing gear has a ratio of 15.3 to 1. Input and output shafts are on the same centerline.

This concept has been achieved first by the basic simplicity of the design. The engine-compressor unit is completely self-sustaining. All required auxiliaries are driven by direct power take-offs from the engine itself. There is no dependence upon secondary auxiliary drivers.

Secondly, the engine gear, compressor, and other station components were selected on the basis of absolute minimum maintenance cost.

Thirdly, the station is fully automated to eliminate the requirement for operating personnel.

Fourthly, the engine fuel consumption has been reduced to the lowest point consistent with dependable, low maintenance operation.

Station Design

The building design is similar to the original concept used in existing Columbia Gulf engine-driven centrifugal stations. This basic approach is one of maximum safety and minimum maintenance and includes such features as (a) all high-pressure gas outside the engine room, (b) extensive use of precast concrete columns and beams, (c) concrete firewall separating engine room from compressor and high-pressure piping, (d) automatic fire protection system.

The building housing the engine-driven centrifugal compressor also utilizes aluminum sandwich walls with perforated inside panels for sound attenuation and a row of windows for increased interior lighting.

The compressor also has been completely enclosed to facilitate maintenance in inclement weather. All control and auxiliary equipment is housed in an adjoining space, divided into a control room and an auxiliary room.

Automation

The operational control of this compressor station will be from the Central Control Center at Nashville, Tennessee. The dispatcher will be able to completely control the operation of the engine-compressor unit by monitoring the required operating information that will be displayed at Nashville.

All operational commands and displayed information is transmitted by a digital pulse system over leased lines. In the event of communications failure between Hampshire and Nashville, the station will continue in automatic operation satisfying the last discharge pressure set-point command received. The engine and station are fully protected with emergency shutdowns at all times.

The adjoining reciprocating compressor station was in attended semi-automatic operation until September 1960 when it and four other Columbia Gulf reciprocating stations went on remote unattended operation.

The automation of the reciprocating stations is unique in that all controls are self-contained at the station, the discharge pressure order being the only command from Nashville. The local station automatic control equipment determines the number and speed of engines required to maintain the discharge pressure order.

The Clark TPV-10 engine-driven centrifugal unit is operated remotely

and unattended. The centrifugal unit generally will be operated at rated load, the reciprocating units taking the load swing to maintain the ordered discharge pressure. The centrifugal unit will operate over its design speed range of 270 to 360 rpm as pipeline flow varies.

TPV Engine

The heart of the Hampshire engine-driven centrifugal station is the Clark TPV-10 engine. Clark first recognized the need for a dependable power pack several years ago and conducted several years of basic engine research in this direction.

It was felt that an engine to best satisfy the requirements of pipelines and other industries should incorporate certain basic design concepts.

First, the engine must possess extreme reliability. Reliability can best be achieved by a simple, uncomplicated design.

Secondly, the maintenance cost of the equipment must be at an absolute minimum. This also can best be accomplished by an uncluttered design with as few wearing parts as possible.

Thirdly, the efficiency must be as high as possible without compromising reliability or maintenance.

The decision was made that these goals could best be achieved by a 2-cycle turbocharged design and in early 1958 the manufacture of the TPV-10 engine was begun. The engine now installed at Hampshire was first put on the test block in Olean, New York, in February 1959 and run for approximately seven months before shipment to Hampshire.

The 10-cylinder engine is the smallest of the TPV line, which includes a 12 and 16-cylinder engine as well. The 12-cylinder engine is rated at 4800 bhp and the 16-cylinder engine at 6400 bhp. Specifications of the complete line are included in Table 1.

Basically, the TPV engine is an adaptation of the TLA line. The first TLA engines were installed at Hampshire in 1952. The principal modifications from the TLA line is the Vee configuration, higher power cylinder compression ratio for higher thermal efficiency, and a larger diameter crankshaft to handle the loading characteristic to rotating equipment. Although the de-

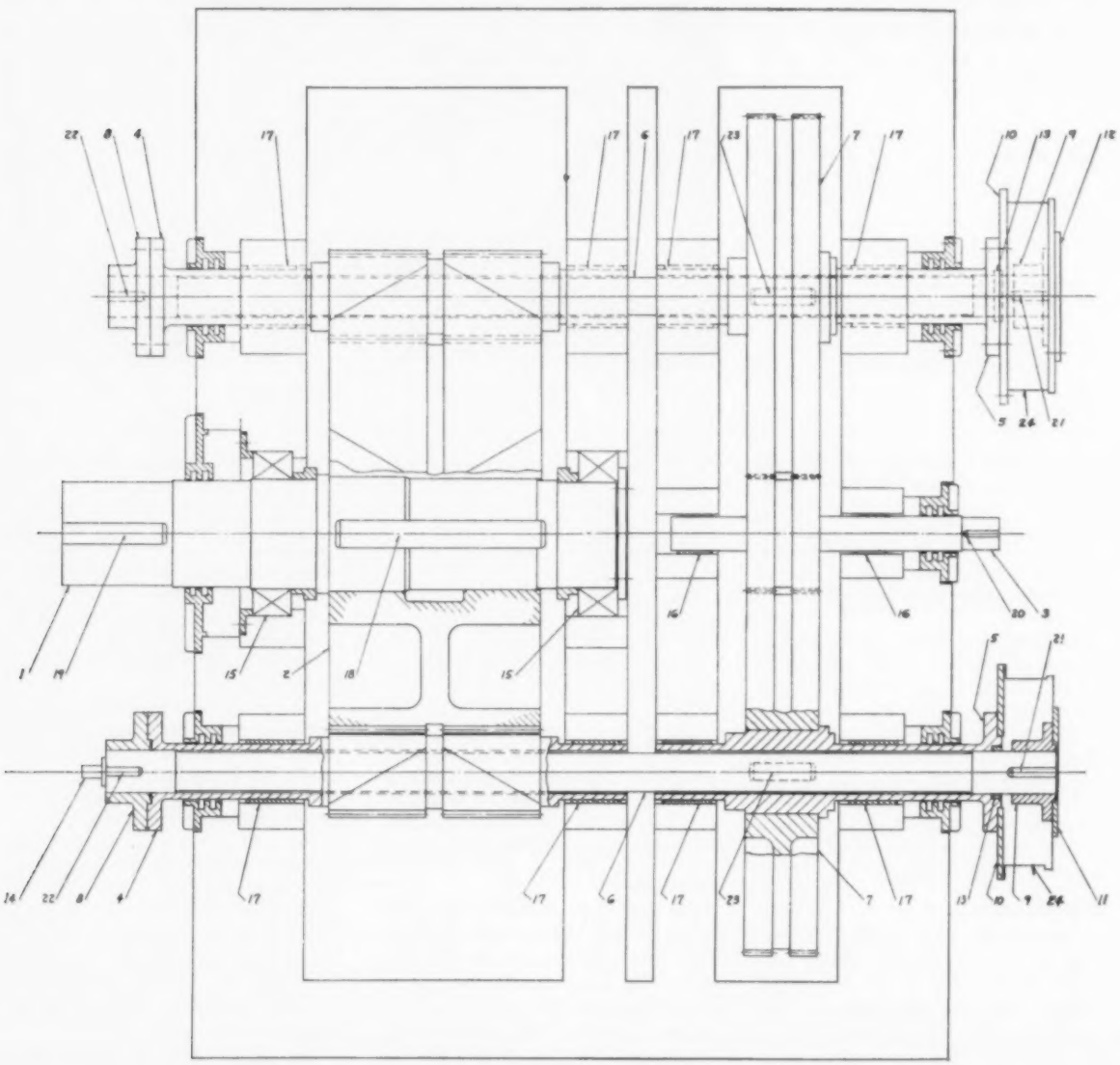
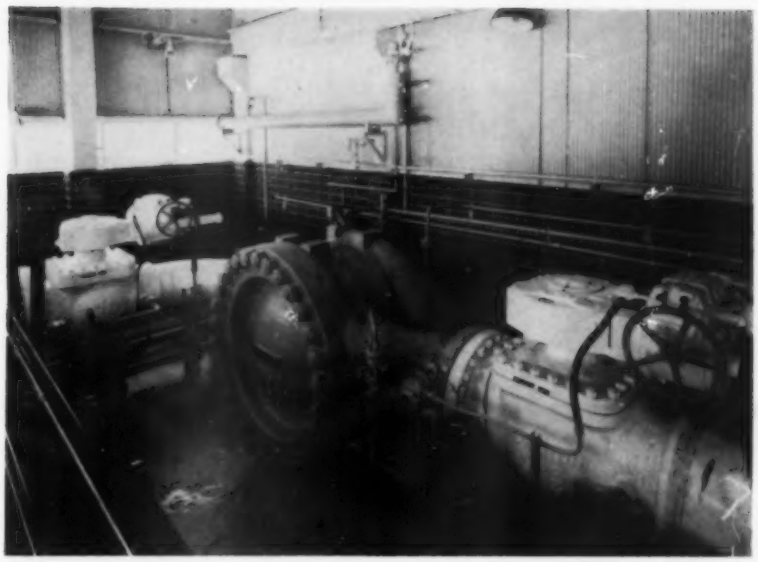


FIG. 1. Speed increasing gear incorporates an "in line-locked gear" train.



Centrifugal compressor at Hampshire station is a single-stage unit that incorporates a removable volute. Thus the machine can handle high head-low flow conditions when a pipeline is first opened, and later can be adapted for low head-high flow conditions with the insertion of new internal components.

tailed testing has not been completed at this time, it is anticipated that the fuel consumption will be in the range of 6600 Btu per bhp-hr.

Speed Increase

The basic gear design incorporates an "in line-locked gear" train. The input and output shafts are on the same centerline. The gear is rated at 4800 hp continuous at 360 rpm input speed. The gear ratio is 15.3:1.

The gearing is double helical, hobbed after heat treatment and accurately balanced. The lubrication system is common with the engine, having equalizing lines between gear and engine. Both intermediate assemblies are of quill shaft design and each are equipped with an airflex coupling. These two features are effective in dampening torsional peaks.

The power path (see Fig. 1) is through the input shaft (Item 1) to the tooth meshes on each side of the low speed gear (Item 2). It is then transmitted through flanges (Items 4 and 8) and solid shafts (Item 6) to the airflex couplings (Item 24) from where it passes through the hollow high speed gear shafts (Item 5) to the high speed gears (Item 7) and finally through the two mesh points to the common high speed pinion (Item 3) which is integral with the output shaft.

Centrifugal Compressor

The pipeline booster is the standard 24 by 24 low ratio, high volume pipeline compressor. It has a large exterior casing, a removable volute (internal assembly) and removable guide vanes. The pitch of the guide vanes can be varied to maintain peak efficiency over a wide range of operating conditions. At maximum engine speed the compressor will be spinning at 5500 rpm. The compressor design point is at 83% adiabatic efficiency and a volume of 850,000,000 cu ft per day.

The compressor was designed to handle future pipeline volumes and at the present volume the adiabatic efficiency is in the vicinity of 75 to 80%.

Performance To Date

Since the unit first went on the line June 10, 1960, it had logged approximately 1500 hours of operation when this was written. Torsiograph readings have been taken, verifying that the designed operating range of 270 to 360 rpm is free of critical vibration. The unit has been operated over the complete range of brake horsepower loads of from 2100 at minimum speed to as high as 4600.

Although it is slightly premature for a final evaluation, all indications are that this station satisfies all initial design requirements, that is, that the 2-cycle turbocharged engine is entirely satisfactory as a variable speed prime mover, and that it will accomplish reductions in cost of service on future compressor stations. ★ ★ ★

TABLE 1. Specifications—Clark Model TPV 2-cycle gas engine.

	TPV-10	TPV-12	TPV-16
Horsepower	4000	4800	6400
Rpm	330	330	330
Power cylinders			
Number	10	12	16
Bore	17″	17″	17″
Stroke	19″	19″	19″
BMEP	110 psi	110 psi	110 psi
Power piston rings			
Compression	6 (1½″)	6 (1½″)	6 (1½″)
Oil wiper	2 (1½″)	2 (1½″)	2 (1½″)
Master connecting rod			
Length	50″	50″	5″
Bolts	2 (1½″)	2 (1½″)	2 (1½″)
Link rod			
Length	36.5″	36.5″	36.5″
Bearings – precision			
Main	(5) 15½″ x 8½″	(6)	(8)
Thrust	(1) 15½″ x 11″	(1)	(1)
Crankpin (master)	(5) 14″ x 9″	(6)	(8)
Link rod pin	(5) 7″ x 9″	(6)	(8)
Wrist pin	(10) 7″ x 7″	(12)	(16)
Flywheel			
Diameter	64	64	64
Face	10	10	10
Weight	5400#	5400#	5400#
Magneto speed (pulse generator)	1 x eng. speed		
Oil gear pump capacity	660 gpm	880 gpm	1000 gpm
Engine weight	210,000 lb	250,000 lb	327,000 lb
Pipe connections			
Exhaust	30″–150#	(2) 24″–150#	(2) 30″–150#
Air filter connection	24″–150″	(2) 20″–150#	(2) 24″–150#
Cooling water pipe inlet	6″–150#	6″–150#	8″–150#
Cooling water pipe outlet	8″–150#	8″–150#	10″–150#
Gas inlet pipe	3″–150#	4″–150#	4″–150#
Starting air	2″ threaded	2″ threaded	2″ threaded
Oil inlet	4″–150#	6″–150#	6″–150#
Oil outlet	6″–150#	6″–150#	8″–150#
Scavenging air cooling water-inlet	4″	4″	6″
Scavenging air cooling water-outlet	4″	6″	6″
General dimensions (engine only)			
Length (flywheel to oil pump)	19′–1″	21′–8″	26′–10″
Width	11′–2″	11′–2″	11′–2″
Height	13′–2″	13′–2″	13′–2″

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Shell Pipe Line Corporation

Shell Solves Problem of

shipping volatiles with crude

Automatic vapor pressure recorder-controller developed to allow optimum injection of high vapor pressure products into crude stream

CRUDE OIL PIPELINES have been called on to accept an increasing amount of high vapor pressure natural gasoline plant products in recent years. Because of the properties of these products and the physical limitations of crude oil pipelines they must be transported as crude-volatile blends.

The economic advantage of shipping by pipeline and the increased production of gasoline plant products have encouraged shipment from the field to more centrally located refineries by existing crude lines.

The increased vapor pressure of the crude-volatile blends, however, has on occasions hampered operations of crude oil systems. Loss of revenue has been experienced from high evaporation losses, spillage from boiled tanks, and the necessity to maintain high back pressures to avoid pump cavitation.

The injection rate of high vapor pressure products into crude lines has been controlled by various methods. Ratio control based on known vapor pressures of the volatile and the crude in conjunction with testing of the blend vapor pressure has been practical for some years. This method, however, can be used successfully only where equipment and qualified personnel are available on a 24-hr per day basis. But this is not possible at remotely operated stations or in the field.

Control by a prearranged volatile pumping rate also has been used but not satisfactorily because high vapor pressure slugs are often formed. Setting the pumping rate at a conservative value helps eliminate this problem but does not allow the maximum use of the line for transporting volatiles.

Paper presented before American Society of Mechanical Engineers, Mechanical Engineering Conference, New Orleans, September 19-21, 1960, under title "Automatic Vapor Pressure Controller for Optimum Volatile Injection Into Crude Lines."

With the advent of World War II the need to move natural gasoline plant products from the field to refineries via crude lines presented the problem of vapor pressure control. A vapor pressure recorder was developed and used throughout the war at various locations as an aid in bringing about a safe increase in the volatile content of crude lines.

The desire to increase the pipeline movement of gasoline plant products from remote locations in the field initiated the development of the vapor pressure recorder-controller described.

This instrument has satisfactorily controlled the injection rate of butane and other high vapor pressure gasoline plant products into crude oil lines.

Injection Problems

A lengthy study of the injection of high vapor pressure natural gasoline plant products has been primarily concerned with the shipment of volatile-laden crudes through a system of crude lines extending from New Mexico to the St. Louis area. Volatile-laden crude tenders in this system consist of blends of up to seven different crudes with as many as seven different natural gasoline plant products. These products include a number of natural gasolines and butane; all will be referred to simply as volatiles. The Reid vapor pressures of the crudes vary from 4 to 7 psi, whereas the Rvp's of volatiles vary from approximately 13.5 to 65.0 psi.

The increased gasoline injection into the system mentioned above was accompanied by the usual high vapor pressure problems of high evaporation losses, boiling within tanks, and vapor locking. Following a study of the injection procedures, pumping rates for each injection point were set well below the calculated tolerable maximum,

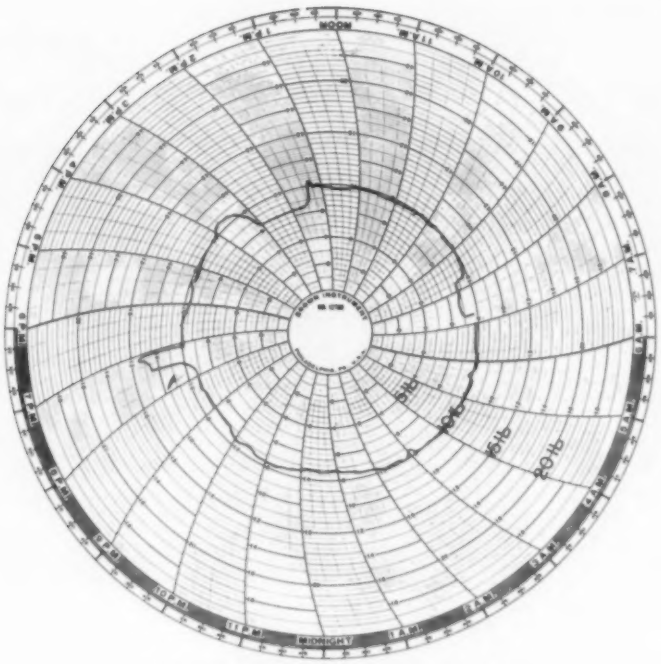


FIG. 1. Record of vapor pressure when volatile injection is controlled by pumping rate.

and the hours for injecting were increased in order to prevent a reduction in the amount of gasoline products injected per day. Operations were substantially improved; however, even after years of experience, they are not entirely satisfactory.

One of the major problems inherent in the transportation of volatiles in crude streams is the occurrence of high vapor pressure slugs of 5 to 30-min duration. The primary cause of this is the unscheduled stoppage of, or a significant decrease in, the flow rate of the crude stream while the gasoline plants continue to inject volatiles at the preset rate. The resulting high vapor pressure slugs may cause boiling within tanks, vapor locking, pump cavitation, and other problems associated with high vapor pressure. A ratio controller at each injection point would eliminate this problem but would not eliminate others noted below nor permit maximum utilization of the crude line because the controller must be preset to conservative values.

High vapor pressure slugs also have been caused by the additive effect of two or more volatile injections into the same portion of the crude tender.

In some cases it was found that the gasoline plant pumping rate had been inadvertently set too high.

At times the gasoline plant injection rate has been set too high because calculations were based on incorrect vapor pressure values for either the crude or the volatile or in some cases both.

These are some of the causes for excessively high vapor pressure portions in mixed crude-volatile streams. To effectively eliminate all problems with a single instrument, this instrument must continuously monitor the stream vapor pressure and control the volatile injection rate to maintain the vapor pressure at a preset value. Fig. 1 is a typical recording that shows the variation in vapor pressure of crude-volatile blends when the volatile injection is not controlled, but set only by the volatile pumping rate.

Crude Pipeline System

A simplified flow diagram of the crude system is shown in Fig. 2, as some knowledge of its operation is necessary for an understanding of the overall problem. Volatile-laden crudes occupy approximately 100% of the available space in segment I, 30 to 40% of the available space in segment II, and approximately 55% of the available space in segment III.

Four volatile injections in the first segment of the system brings the Reid vapor pressure of the crude-volatile blends to about 10 psi during the winter months and the volatile content to as much as 9% volume.

Gasoline plant products are injected into the volatile-laden crudes at two locations on segment II of the system. The injection of relatively large amounts of butane, Reid vapor pressure of 65 psi, at the first location is of primary interest. A vapor pressure recorder-controller was installed here to record the vapor pressure of the crude-butane blend and indirectly to control the butane injection. The injection of a gasoline, having a Reid vapor pressure of 32 psi, at the second location increases the volatile content of some portions of the volatile-laden tenders to 12% volume or more during the fall and winter months. A vapor pressure recorder-controller at the second location limits the volatile injection rate only when the vapor pressure of the main stream exceeds a preset value; otherwise, the injection is controlled by other means. Farther downstream a vapor pressure recorder-controller can be utilized to increase the injection rate of a low vapor pressure crude if the main stream vapor pressure exceeds the maximum permissible value.

Portions of the volatile-laden tenders go into tankage at two stations on segment II of the system; however, normally the major portion is tight lined from one end of segment II to the other. The same portion of a tender does not always go into storage at both places.

The volatile-laden tenders ordinarily go into storage at the end of segment II, but at times these tenders go directly to segment III.

Experimental Installation

Control of the butane injection in segment II alone was not sufficient to permit maximum utilization with safety, as the 32-psi gasoline injection was downstream. Both injections would have to be controlled to obtain the desired results.

Irrespective of this the butane injection on segment II of the system offered ideal conditions for evaluating the experimental model of the vapor pressure recorder-controller. Here an unlimited supply of butane and adequate pump capacity gave reasonable assurance that a sufficient quantity of butane could be injected to raise the vapor pressure of the lowest vapor pressure crude to the highest desired value. Equally important was the fact that the volatile-laden tender passing this point would include two to four crudes that would vary in vapor pressure. Variations in Reid vapor pressure values from 4 to 12 psi were common.

ABOUT THE AUTHOR

P. R. SCOTT received his BS degree in chemistry from the University of Houston in 1949. He joined Shell Oil Company in 1951 as a chemist at the Houston Refinery after two years' experience in a commercial testing laboratory. The last three of the five years with Shell Oil were spent in product formulation and quality control. He was transferred to Shell Pipe Line in 1956 and has been a project engineer in the development laboratory most of the time since then.

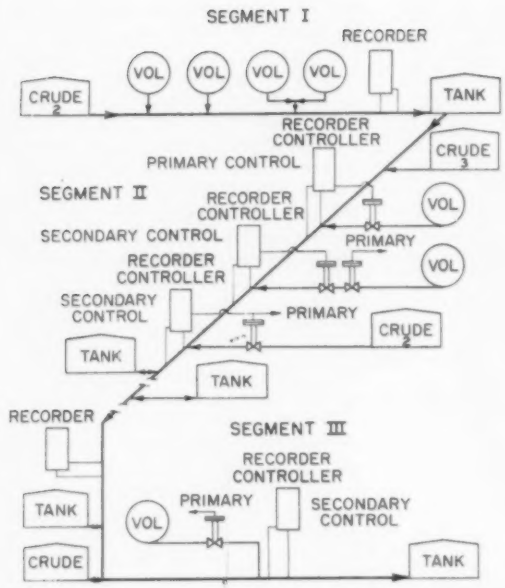


FIG. 2. Flow diagram of segments I, II and III of a system transporting volatile laden crude.

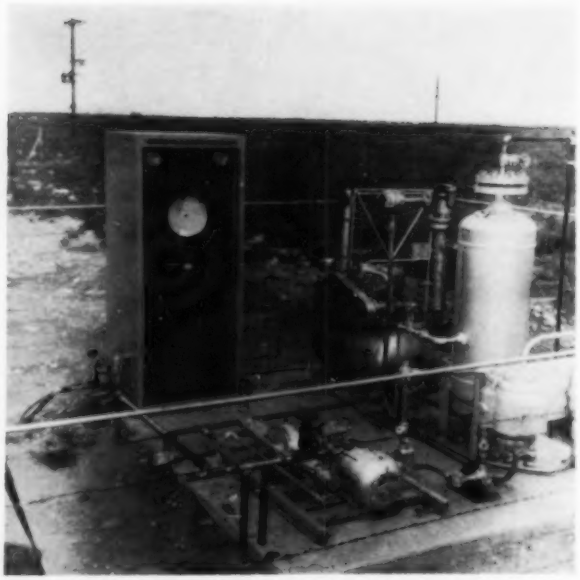


FIG. 3. Typical field installation of a vapor pressure recorder-controller.

Butane was injected into the side of the 20-in. diam crude line through a standard 4-in. welded flange connection. An air-to-open pneumatic valve operated by the vapor pressure recorder-controller was installed in the 4-in. line approximately 60 ft from the injection point. A ¼-in. sample tap (through ¾-in. fittings) was made in the top of the crude line 25 ft downstream from the injection point. To reduce the time lag small volume piping was installed to supply the slip stream to the instrument.

The total time required for a small quantity of the blend to travel from the injection point to the sensing element within the vapor pressure instrument was calculated to be 20 to 25 sec.

Fig. 3 is a photograph of this instrument at this location.

Calibrating and Testing

Tests were made to determine the elapsed time between the opening of a plug valve on the injection line and a vapor pressure change indicated by the instrument. It varied from 18 to 25 sec.

A direct calibration of the instrument was made in the field. A sample tap was installed on the line supplying the instrument. Reid vapor pressure samples were taken at this point directly into the sample container of the Reid apparatus while maintaining conditions to obtain a representative sample. The instrument reading was recorded at the same time the sample was taken. This value was then compared with the Reid vapor pressure value for the sample determined in accordance with ASTM-D323-56. A calibration curve was then drawn from data accumulated for various vapor pressure crudes (Fig. 4).

Vapor pressure values for samples taken from the instrument supply line were compared with values for samples taken 7.15 miles downstream to establish whether the sample line was properly located. Agreement of the vapor pressures for samples taken at the two points from the same portion of a blend indicated the sample stream represented a homogeneous blend of the crude and butane when the butane was less than 2.7% volume. At higher percentages of butane the vapor pressure of the sample stream was too high.

The limited data available indicate that the difference increased in a linear manner from zero for 2.5% butane blends to 2.1 psi for 6.9% blends.

The sample tap was later moved and is now located 45 ft downstream from the blending point and 45 deg below top center. Tests conducted some time ago indicate that for one instrument this placement of the sample outlet tap is satisfactory up to 5% volatile blends whereas for another instrument it is not. Mixing nozzles equally spaced around the main line are recommended and should be installed at future installations provided no other fittings are in the crude line to increase mixing.

Determining Safe Limits

To realize maximum utilization of the various crudes comprising the volatile laden tenders for transporting the volatiles injected in segment II, it was necessary to establish maximum permissible vapor pressure limits and to control the injection of the gasoline and butane to maintain these limits.

A thorough study of the shipment of a high vapor pressure volatile tender (Reid vapor pressure of 15.8 psi) was made. It was concluded from this study and from later operating experience that crude having a Reid vapor pressure of 16 psi could be transported without any unusual operating problems, provided: (1) Line and tank temperature are 80 F or below, (2) the atmospheric pressure at breakout tankage exceeds 13.5 psia, and (3) floating roof storage tanks are used. These findings are consistent with those reported in API Bulletin 2513.

Experimental Operating Experience

The field installation of the experimental vapor pressure recorder-controller was completed several years ago. The instrument satisfactorily controlled the injection of the butane to maintain the Reid vapor pressure of the crude-volatile blend within ± 0.3 psi of the selected vapor pressure. Pumping facilities at the gasoline plant were not satisfactory during the initial testing period because the pressure on the butane line could not be kept constant. Because of the pump arrangement the pressure at the control valve varied by as much as 100 psi when the injection rate changed. Despite this radical pressure variation the instrument controlled the injection to maintain a uniform vapor pressure blend.

Fig. 5 is a 24-hr record taken from the vapor pressure recorder-controller. At 3:30 p.m. of one day the vapor pressure recorder was tested and put on stream. The index was set at 14 psi. The instrument recorded the vapor pressure of the passing stream until ap-

proximately 1:30 a.m. of the next day. Then the block valve on the injection line was opened and the pumps at the gasoline plant were started. The instrument controlled the butane injection rate to maintain the desired vapor pressure in the crude line. The data for this 24-hr run are given in Table 1.

Table 1. Butane injection.

Time	Average injection rate, BPH
1:25- 2:30 a.m.	253
2:30- 4:30 a.m.	302
4:30- 6:30 a.m.	148
6:30- 8:30 a.m.	240
8:30-10:30 a.m.	253
10:30-12:30 a.m.	301
12:30- 2:30 p.m.	262
Average to 3:45 p.m.	252
Calculated average based on vapor pressure of various crudes and butane	260
Crude flow rate, BPH	9350

The instrument's operation improved and the vapor pressure variation was reduced to less than ± 0.3 psi after the pumping arrangement was revised and the pressure control system was improved at the gasoline pump station.

As control was now available, the shipper requested that each tender designated for carrying volatiles be blended to the same vapor pressure. A vapor pressure setting was calculated using the vapor pressures of the various crudes comprising these tenders, the average volume of crude available per day, the average vapor pressure of the butane, and the desired butane shipping rate. The vapor pressure recorder-controller was then set at the calculated value. The instrument controlled the butane injection rate to give a uniform vapor pressure blend and kept the average injection rate within 3% of the desired value. During this time injection rate varied from 140 to 550 bph because vapor pressure of crudes passing the blending point changed.

Based on the operating experience gained from this instrument, it was determined that the principle of operation employed was sound and that similar instruments could be used at numerous locations to monitor and control vapor pressure of various hydrocarbon streams.

Recent Operating Experience

The original experimental vapor pressure recorder-controller has been replaced and three others installed on segments II and III. A vapor pressure recorder of the same basic design also was installed to record the vapor pressure values for crudes transported through the first segment of the system. It is necessary to know the vapor pressure of the crude from segment I to calculate the maximum amount of butane and gasoline that can be injected into segment II if the vapor pressure recorder-controllers are inoperative.

After the normal start-up period, the instruments controlled satisfactorily and on occasions acted to prevent high vapor pressure slugs. Approximately 45,000 more barrels of butane were shipped by the crude system during the months of October and November than could be expected from past experience. This increase was attributable to the control of vapor pressure and higher vapor pressure limits.

How the Instrument Works

An especially designed ejector shown in block form in the flow diagram is the heart of the vapor pressure recorder-controller (Fig. 6). This device is approximately 1 in. by 2½ in. All other components are present to maintain the proper flow conditions, record the ejector pressures, interpret them, and reestablish this pressure should it deviate from the desired value.

The first function of the instrument is to heat a sample of a well mixed crude-volatile stream in an in-line heater. A pressure regulator immediately downstream then reduces the pressure to a value that allows the vapor pressure sensing device to function properly. The temperature control sensing element located adjacent to the sensing device maintains the sample stream at the proper temperature by regulating the in-line heater through a feed-back system. The *kinetic* vapor pressure of the stream is determined by the vapor pressure sensing device and transmitted to the recorder-controller. After passing through the sensing device the stream goes to a sump.

The vapor pressure recorded by the instrument is neither the true nor the Reid vapor pressure. A linear correlation does exist, however, between the vapor pressure recorded by the instrument at specific operating conditions and the Reid vapor pressure of the sample stream (Fig. 4). The reproducibility for Reid and instrument vapor

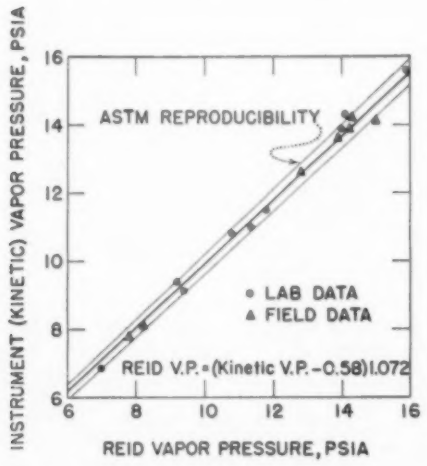


FIG. 4. Reid vapor pressure vs instrument vapor pressure.

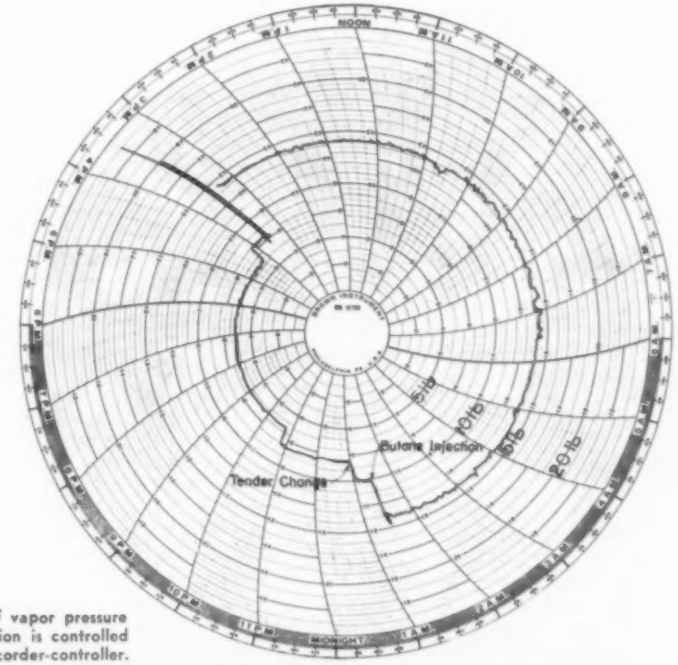


FIG. 5. Record of vapor pressure when volatile injection is controlled by recorder-controller.

pressure values was found to be as good as the reproducibility for two operators using different Reid equipment. The vapor pressure recorded by the instrument is called the *kinetic* vapor pressure since the ejector device works on the well-known principle of increasing the kinetic head until the static head at the nozzle discharge reaches the vapor pressure of the liquid.

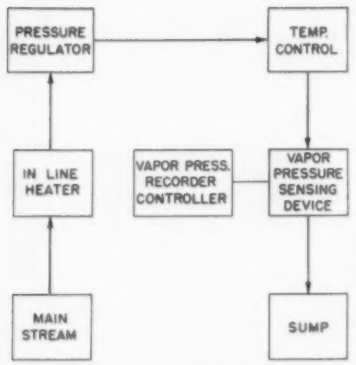


FIG. 6. Schematic flow diagram of sample system.

The instrument's safety system was designed to afford maximum protection to the line receiving the high vapor pressure products as well as to protect the instrument in case of abnormal operating conditions. If the flow conditions through the instrument are such that its reading is not reliable, or if a power failure occurs, the control valve on the volatile line is closed. When the flow in the main line stops, abnormally high vapor pressure blends are formed at the injection point and injection valve closes.

Summary

The instrument will control the volatile injection at a determined optimum rate. This allows maximum utilization of crude pipelines for transporting high vapor pressure products. As a result the pipeline operator benefits from the increased volume, shippers reduce transportation costs, and the refiner receives uniform vapor pressure blends, which help smooth refinery operations.

The performance of the recorder-controller suggests that it is usable to control the blending, separating, and detecting of many streams where the vapor pressure is a dependent variable.

Acknowledgment

The author wishes to acknowledge the contributions of many Shell Pipe Line Corporation personnel, especially those of C. H. Goodnight. Special appreciation is extended to the personnel of The Texas Pipe Line Company whose cooperation and aid made some of the field studies possible. ★ ★ ★

Pipeline Industry Loses Prominent Figure:

OSCAR R. BURDEN

OSCAR R. BURDEN died of a heart attack in Tulsa, Oklahoma, September 10, and with his passing went a widely known figure in all branches of the petroleum industry. He was one of the top pipeline construction contractors, for many years he was a high official with a major pipeline operating company, and he engaged world-wide in oil well drilling contracting.

Oscar Burden was born in Poplar Bluff, Missouri, but the family moved to Montpelier, Indiana, when he was quite young. It was during his school years here that he gained his first pipeline experience, working week ends, holidays, and summer vacations for the Indiana Pipe Line Company and Manhattan Gas Company.

Forced by circumstances to provide for the family, he had to give up school and take a full-time job in a grocery store. Deciding this did not offer a future, the oilfields beckoned.

His first job was as a rig builder in Tulsa, but a few months later he took a job with The Texas Pipe Line Company as a laborer. This was in 1910 and he remained with the company until 1939.

In 1923 he became assistant manager at Wichita Falls, Texas, and in 1939, when he was division manager, terminated the association to join Panhandle Oil and Refining Company, also of Wichita Falls, as vice president and general manager. A short time later he resigned from Panhandle, but made a deal to take over their drilling rigs and do their drilling on a contract basis. The company operated as Burden-Riley Drilling Company, a partnership. He also formed another partnership, B.&W. Construction Company to lay pipelines and do other construction work.

He was operating these companies when the government decided to construct the Big Inch pipeline as a war measure to move needed crude oil to the eastern area of the United States. Burt Hull of The Texas Pipe Line Company, was selected to head the project and he asked Burden to join him as general superintendent of construction.

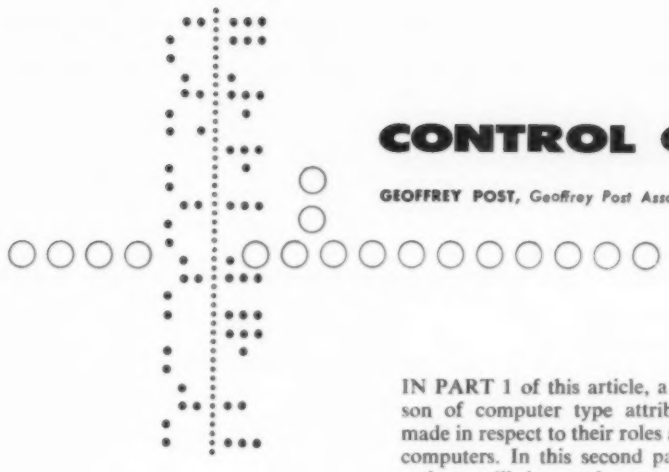
After completion of the Big Inch, it was decided to build the Little Big Inch, and he was asked to remain with these War Emergency Pipelines, so he sold his interests in the Wichita Falls businesses to his partners.

At the close of the war, both lines were leased to Tennessee Gas Transmission Company for gas transportation with Williams Brothers Company having the contract for their operation and maintenance. He was manager for Williams Brothers until the system was sold to Texas Eastern Transmission Corporation.

Began then his first activity in international operations. He went to the Middle East as general manager for Williams Brothers, who had contracted to build half of the pipeline between the Mediterranean Sea and the Persian Gulf — Tapline. Shortly, however, he was asked to become general manager over the entire Tapline construction project and resigned from Williams Brothers. He continued as general manager until the work was discontinued due to the partitioning of Palestine, returning to the States as president of Engineers Limited Pipeline Company of Los Angeles.

Then, in 1949, he purchased a spread of pipeline equipment in Tulsa, Oklahoma, and the O. R. Burden Construction Corporation was formed.

Intervening years have seen the formation of many subsidiary companies, some wholly owned, others jointly owned with others: Tulsa Minerals Corporation, Constructora Burden de Mexico, S. A. de C. V., Universal Engineers & Constructors, Inc., Texas Central Gas Company, Burden International, Ltd., Turriff-Burden, Ltd., Burden Drilling & Pipeline Contractors, and Burden Pan American, Ltd., representing activities in pipeline construction, oil well drilling, gas transmission, petroleum plant construction, and mining.



CONTROL COMPUTING

GEOFFREY POST, *Geoffrey Post Associates, Los Angeles, California*

Part 2:

Computer types applied to pipeline problems

IN PART 1 of this article, a comparison of computer type attributes was made in respect to their roles as control computers. In this second part, applications will be made to a pipeline problem for each of the three types.

The first type considered is the analog computer employed in a facet of a natural gas compressor station control problem. This problem involves certain emergency controls and a small optimization requirement.

The second system considered is the use of a general purpose digital central computer as a master central dispatcher unit for a large multi-line natural gas system including tie-ins with a communications system and data loggers.

The incremental digital computer is shown as a slave station controller applied to the same large system but showing the interesting hybrid nature of this computer type.

Analog Surge Control Computer System

When there are series-parallel combinations of compressors in a heavy duty system application, the surge control problem becomes important not only in safeguarding the compressors themselves but in the optimization problem of operating as close to the surge point as possible with stability, in the interest of efficiency.

Fig. 1 shows the assumed characteristics of a two compressor unit to indicate the nature of the problem.

The problem here is thus threefold: (1) to sense the approach to surge conditions, (2) to prevent entry into the surge region, and (3) to operate as close to the stable side of the surge point as possible without entering the unstable region.

Note in the curves that Compressor I has a surge region involving fairly constant flow conditions for a wide variance of pressure ratio whereas Compressor II has essentially the opposite conditions. The decision as to what to sense is thus a choice between pressure ratio and flow. The practical choice is pressure ratio, because flow is more inaccurate for equivalent cost and inaccuracy of this type can cause a large error in surge control.

Prevention of entry into the surge region is provided by a simple instrument type analog control computer shown in Fig. 2. Operation is as follows:

Electrical output pressure transducers measure P_{in} and P_{out}.

The equations are:

$$P_{out}/P_{in} = P_r, \text{ actual pressure ratio} \quad (1)$$

$$\Delta P = P_{out} - P_{in} = P_{in}(P_r - 1) \quad (2)$$

A differential transmitter produces ΔP. P_{in} is multiplied by a potentiometer multiplier setting representing $(P_r - 1)$ and the signal is fed to a controller whose error signal is the difference between actual P_r and desired P_r. Desired P_r is set by scaling the set point of the controller. The final error equation for the controller is thus:

$$\varepsilon = P_{in}(P_r - 1) - P_{in}(P_r^* - 1)$$
$$\varepsilon = P_{in}(P_r - P_r^*).$$

Where P_r^* is desired P_r.

Variations in P_{in} will affect the difference signal and this is compensated by a second potentiometer on the P_{in} transducer to keep the gain in the error equation constant.

The desired pressure ratio is set by the minimum resolvable increment below the surge point less instrumentation and dynamic tracking errors in the control system. These latter errors are reduced by using an integral mode of control, i.e. integrating amplifiers, so set that if pressure ratio is below the set point, the controller attempts to increase it by closing the blow-off valve to prevent air waste when the controller operates below surge.

Digital Computer Central Dispatching System

A system is required for a large natural gas pipeline complex with the following specifications:

(1) To receive, store, and collate telemetered and manually inserted data for and from 22 compressor stations and subdispatcher units including such items as anticipated gas loads, weather conditions, etc.

(2) Calculate line efficiency and transmission costs.

(3) Make line optimizing computations and generate set point commands for all compressor stations.

(4) Perform special computations daily such as supercompressibility, for example.

(5) Process cost data for accounting machine formats.

(6) Log required data such as custody transfer information, maintenance trends, etc.

(7) Perform command data link operational checks.

(8) Perform periodic self-checking.

Fig. 3 shows the block diagram of the system. Data in binary coded form from outlying stations is transmitted to the antenna and receiver and thence automatically and simultaneously to the communications controller section of the computer and the communications control console. This latter unit displays to an operator the nature and content of the data.

During emergencies or conditions of large data inputs, a special overflow buffer memory is provided to accommodate all inputs for subsequent review. The operator can then overpower the automatic program or allow the information to be sent to the appropriately addressed evaluation and computation section of the main computer store either as part of the compressor station control section or the central computer processor. The solutions and decisions are then sent back to the communications control section for data link language conversion and then over the data link to the proper station or stations.

The central computer processor is actually a second independent general purpose computer in its own right. Although it normally processes the accounting aspects of the problem, it can also provide services of the other computer sections in case of failure. Its most important function is to provide an analytical tool for continuous experimentation in parallel with the existing controller sections to seek their improvement and optimization on a system-wide basis.

Fig. 4 is a flow chart of the typical program of the system. Input variables first will be sorted as to whether or not to display, log, or plot the information. The data is then shifted into appropriate memory channels in designated address areas.

The data is then checked against the special evaluative instructions also stored in the memory. These special instructions include checking the data to see whether the data exceeds certain specified limits, ascertain whether any special calculations are to be made, such as special line material balance, availability of gas, or any other unscheduled normal calculation.

The computer periodically would make line efficiency computations. In these, the computer would proceed to compute and log each station efficiency based on an equation such as follows:

$$KQ^2Lf = Y(P_1^2 - P_2^2) + (Y^2)(\Delta h)(P_1 + P_2)^2$$

Where:

$$\text{Efficiency} = \frac{\text{Q Delivered}}{\text{Q Designed}}$$

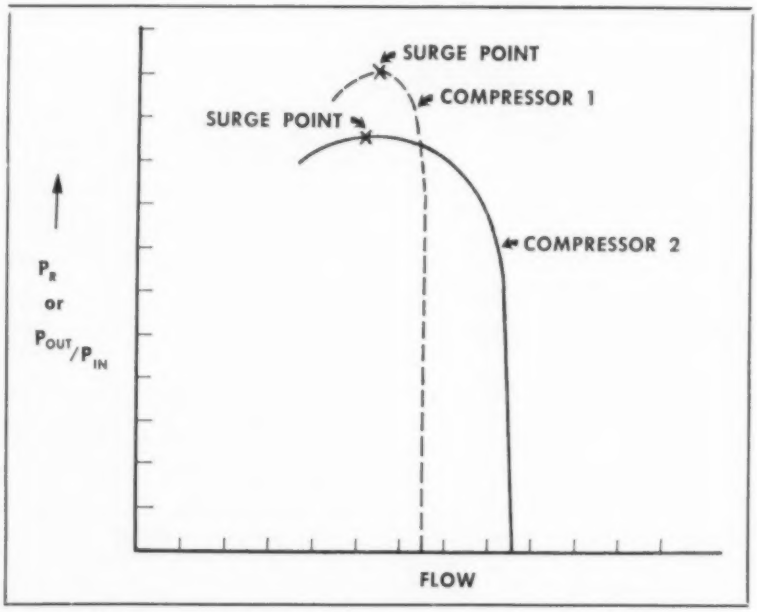


FIG. 1. Compressor characteristics (speed and temperature relatively constant).

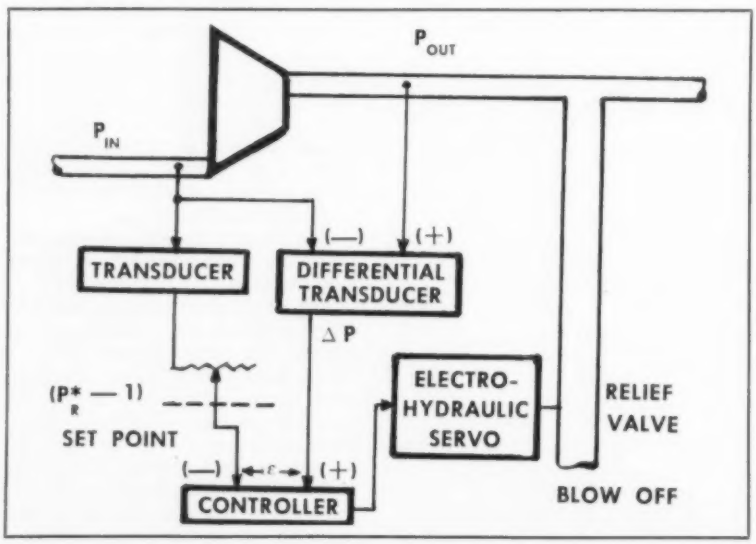


FIG. 2. Analog instrument type surge control computer.

Line efficiencies are calculated every 15 minutes.

Computation would be made of line material balances using the integrated values of Q received from actual flow meters and stored in predetermined memory registers. A material balance for each section of line would be computed and logged along with the material balance for the entire line.

Material balances will be calculated every half hour or on demand. The material balance on demand calculation will be one of the special instructions always contained in the memory.

The cost equation would be the next step of the clocked, sequentially-stored commands. Again, a yes answer commands the computer to perform appropriate cost calculations. The cost equation uses cost values that have been stored previously in the memory, that is, constants for cost of fuel and power for the various compressor stations.

Transportation cost = $(Q_{burned} + Q_{loss})\ (F_1) + (KWH_{consumed})\ (F_2) + F_3$.

The transportation cost will be calculated and logged every hour, and if desired, an output sent to the accounting department. These outputs are consistent with business computer punch card formats.

The computer will periodically make a decision on the logging of variables. Certain variables and only certain measured points need be logged once an hour, on demand, or in special cases when the points approach or exceed a certain limiting condition.

Supercompressibility will be calculated once a day or on demand. Once the master clock determines that the supercompressibility is to be calculated, the computer organizes the data required. First the psuedo critical temperature and psuedo critical pressure are calculated using the following type of formulas:

$$T_c = 128.5 + 90.1\ S + 0.1632\ H + 244\ C$$

$$P_c = 670.7 - 183.9\ S + 0.1028\ H + 683\ C$$

From these, the psuedo reduced properties can be computed:

$$T_r = \frac{T}{T_c} \qquad P_r = \frac{P}{P_c}$$

The value of supercompressibility is then calculated from curves which use T_r and P_r as parameters. Supercompressibility is then stored so as to be available for use in the flow equations. The time at which supercompressibility was calculated is recorded in order to plot the travel of this point south in the gas line.

Custody meter and sale meter flows are used for line efficiency calculations, for accounting purposes, etc. These will be calculated every hour or on demand. The flows come from a flow meter and are corrected for temperature, pressure, and supercompressibility before being logged. Accounting department outputs are made on cards, magnetic tape, or punched paper tape.

A special program provides for an automatic system self-check. If the check is rejected, the operator is signaled and the computer puts itself in a stand-by condition until it receives an okay signal from the operator. This manual over-ride effectively rolls the computer back to its last known error-free condition.

Optimization calculations are an important part of the overall computer program. Every time certain variables change a predetermined amount, the system should be checked for optimization to maintain maximum load factor and system performance at the least practical cost. First, the entire system will be optimized and then the operation of each individual compressor station would be optimized. Optimization of the system and the stations generates certain commands that must be transmitted to the station slave computers.

After optimization, the control commands are checked for reasonableness. Again, if this check is negative, the operator is signaled and the computer is again put in standby. If the commands are reasonable, the set-point channels are reset. In this way, the new set points are placed in a certain channel on the memory disk so as to be readily accessible.

Time commands are transmitted to the individual compressor stations. The receiver at the station will return an echo that will be checked against the command signal. If this check is satisfactory, an execute command will be transmitted. If the echo doesn't check, the operator will be signaled.

After set-point channels have been reset, the computer either goes through the normal sequenced routine again or is available for special computations. One such special computation is the calculation of the volume of gas that can be stored in a line or that is available on demand.

Volume of gas that can be stored in a line at constant rate of flow:

$V = 1.955\ d^2 L P_m K$

d = inside diameter of line, in.

L = length of line, miles

P_m = mean line pressure, psi

$K = \left(\frac{1}{z}\right)^{1/2}$ supercompressibility factor for a gas of given specific gravity at given temperature.

$$P_m = \tfrac{2}{3}\ P_1 + P_2 - \frac{P_1 P_2}{P_1 + P_2}$$

P_1 = inlet pressure, psia

P_2 = outlet pressure, psia

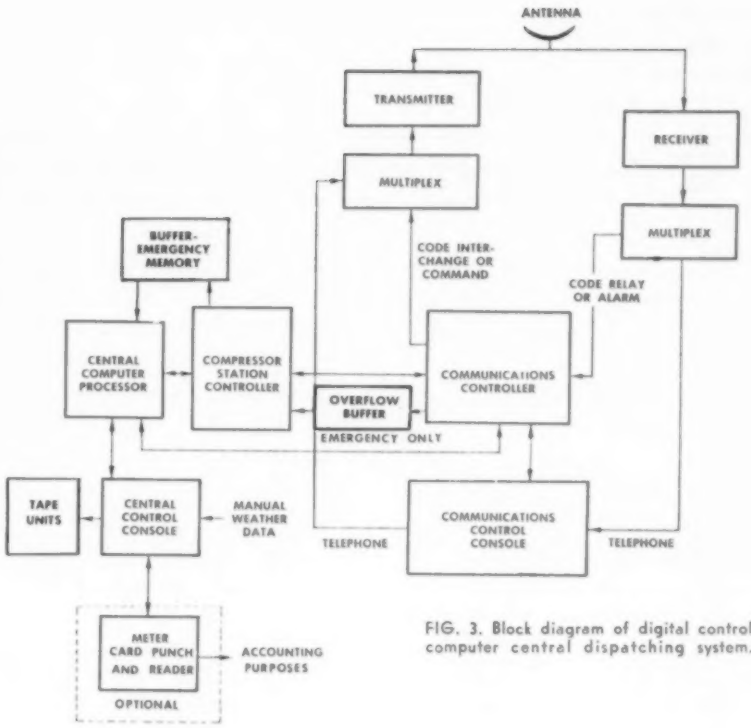
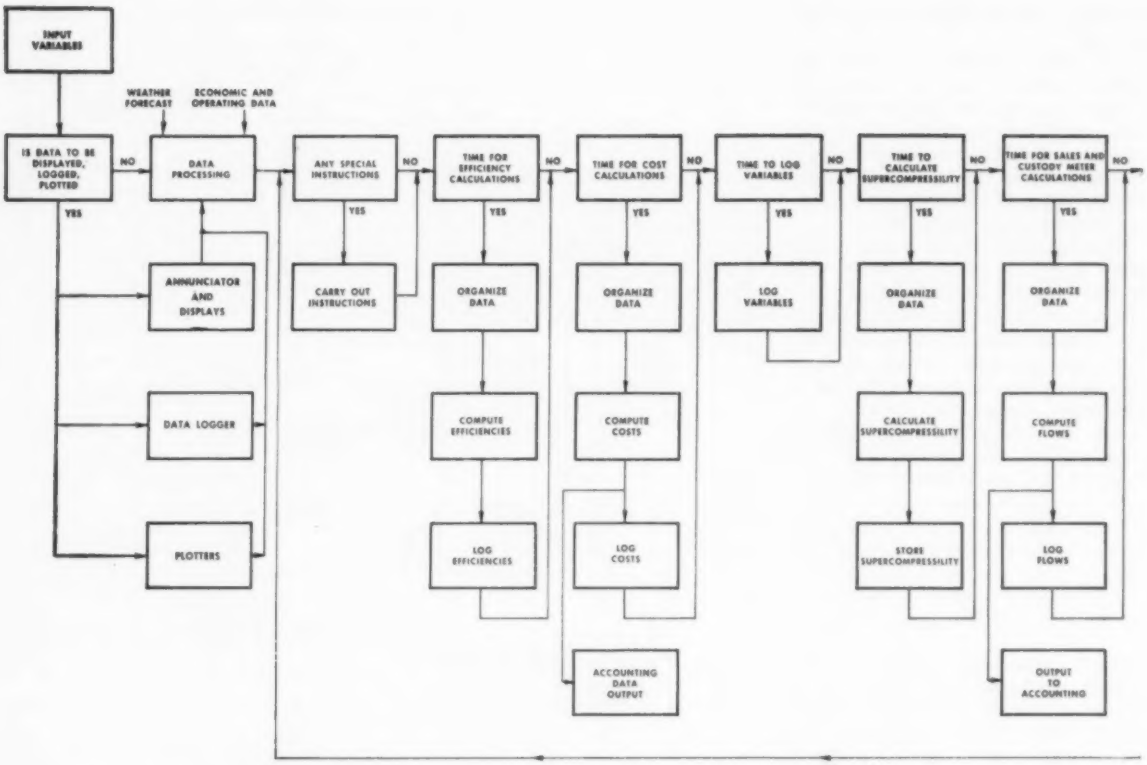


FIG. 3. Block diagram of digital control computer central dispatching system.



To find the quantity of gas that can be stored between the period of low flow and the period of high flow it is only necessary to find V_1 (volume at low flow) by using the low-flow pressures in the P_m calculation and to find V_2 (volume during high flow) by using high flow pressure in the P_m calculation. The difference $(V_2 - V_1)$ is the storage capacity of the line.

Definition of Terms

P_1 = discharge pressure of upstream station, psia

P_2 = suction pressure of the downstream station, psia

Y = deviation of Boyle's law

Q = flow rate, MM cu ft/hr at 60F and 14.73 psia

$$\Delta h = \frac{0.0009384\ S\ h}{T}$$

S = specific gravity

h = change of elevation of pipeline gradient, ft

T = absolute temperature of gas, °R

$$K = \frac{ST(10^{12})}{(6.25)D^5\ (520)}$$

H = heating value of gas, Btu/cu ft

C = volume fraction of CO_2

D = pipe inside diameter, in.

L = distance between elevation points, miles

f = friction factor

F_1 = factor for fuel gas cost

F_2 = cost factor for electricity

F_3 = cost factor for line amortization, labor, fixed costs

Incremental Digital Control Computer

The large dispatching and control system just described can employ smaller slave computers in several large unmanned stations where the economic and system conditions warrant. Such a slave computer for a compressor station is shown to use the flexibility of the incremental digital machine combined with a large memory processor for full station control, which will simplify the costs and complexity of the master machine and also give a further guarantee of reliability of operation if the master fails on occasion.

The system requirements are as follows:

1. Linearizing, scaling, and encoding transducer outputs for data-link transmission.
2. Storage of recently accumulated operating variables for the station in event of data-link outage or station equipment failure.
3. Control of compressor units and valves within the station.
4. Self-checking at periodic intervals.
5. Miscellaneous data processing functions as necessary, such as special procedures under certain load conditions.
6. Logging of station and unit functions where required.
7. Fail-safe operating mode for station.
8. Programming and monitoring alarm scanning.
9. Control of digital communication through the data link and collation of such interrogations.

This small computer monitors and controls internal station functions including internal optimization and communication. Thus, decision-making functions for the station and the system as a whole are transferred to specific computers in accordance with their overall control responsibilities.

Compressor station data processing is divided between the station slave computer and the master system. Optimizing and control computations relating to the compressor station's role with respect to the system are executed by the master. The slave station computer is only concerned with optimization and control calculations peculiar to its station. Line system optimization includes the effect of forecasted gas demands, system operating conditions, short and long range weather forecasts and results in the most efficient load

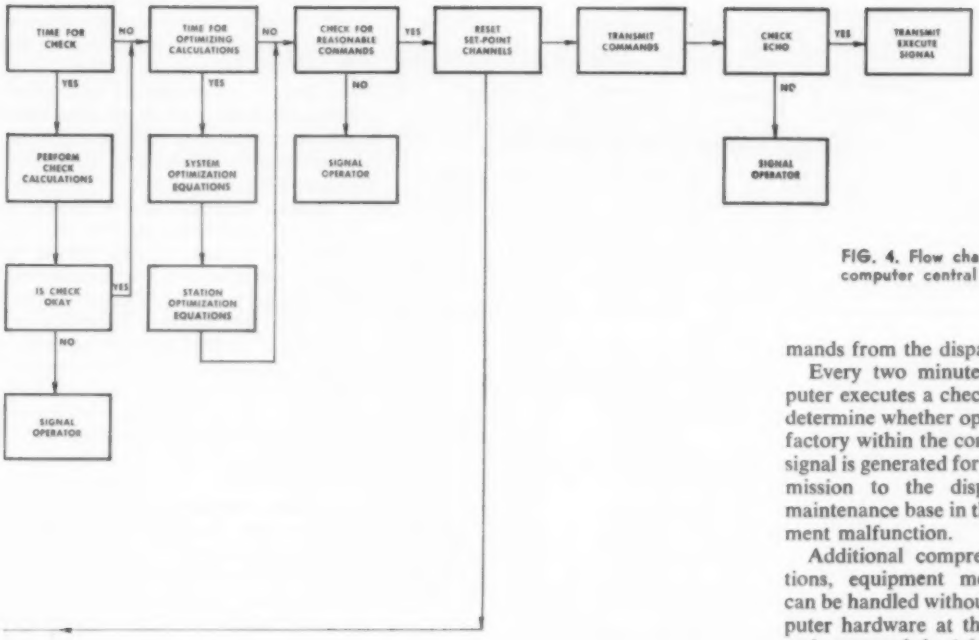


FIG. 4. Flow chart of digital control computer central dispatching system.

division between compressor stations on the line. Station optimization is relegated to the division of load among a given station's compressors, minimum maintenance controls, and fail-safe measures.

Thus, the computer controls manual, automatic or remote start up, shut down, and full operational control of the station. Unit controls operating through station controls allow automatic operation of units.

Fig. 5 is a block diagram of the slave station. The station computer operation is as follows:

Instruments to read pressures, temperatures, flows, etc., at the station are scanned at regular intervals. The scanning frequency is adjusted on the basis of the station and line dynamics and other factors. After scanning, the instrument readings are converted to digital pulse trains and transmitted to the station computer's memory and the alarm functions are transmitted to the dispatcher. Key data is retained in the memory in event of data link failure until communication is restored. Certain information valuable to maintenance personnel in diagnosing station malfunctions also is retained inasmuch as the specially stored data can be read out on demand.

Calibration corrections of instrument data are accomplished on the station computer. Local instruments are linearized, scaled, and zero-offset in the station computer since performing these functions on the slave computer reduces the load of unnecessary functions that could be delegated to the dispatcher. If new instrumentation is placed in the compressor stations, calibration curves stored on the slave computer can be modified through simple reprogramming. No additional equipment is required.

Station computers receive from the dispatching center commands relating to the station discharge pressure, flow, etc. Upon receipt of this data, the station computer runs through optimizing calculations relating station and unit controllable variables to the new station performance.

This program contains typical compressor performance curve data. These performance curves as well as the current operating conditions and running times of unit compressors are used in arriving at the new station operating conditions. The slave computer will initiate control signals to start or stop the required number of compressors in the proper sequence. Moreover, it generates unit control parameters and provides information to the unit controls to allow compressor units to respond to the new performance level. The slave computer can bypass the entire compressor station or individual units as a result of alarm conditions or commands from the dispatcher.

Every two minutes the slave computer executes a check performance to determine whether operations are satisfactory within the computer. An alarm signal is generated for microwave transmission to the dispatcher and the maintenance base in the event of equipment malfunction.

Additional compressors at the stations, equipment modifications, etc., can be handled without additional computer hardware at the station. This is so because of the inherent large memory capacity characteristics of the station computer. Changes or program additions are readily made to the computer with a minimum of interference to station operations. Manual controls are provided to facilitate program modification.

Automatic logging of off-normal station variables (or on demand, when maintenance personnel are at the station) is accomplished through the slave computer. All trouble signals are grouped in a special code format for transmission on the data link.

Dispatcher interrogation of information is accomplished through a stored program in the slave computer called into play for this purpose. The regular programs are available to reject dispatcher commands calling for abnormal station operating parameters that cannot be achieved without dangerous overloading. Station start-up, shutdown, and bypass are accomplished through the slave computer upon direction from the dispatcher or manually at the station.

The station computer is not housed in an explosive-condition area; however, the local compressor unit control packages, which respond to the slave computer, are located in the hazardous environment and are explosion-proof. Emergency shut-down of the station is directed by the computer in the event of dangerous situations such as explosive mixtures, fire, etc.

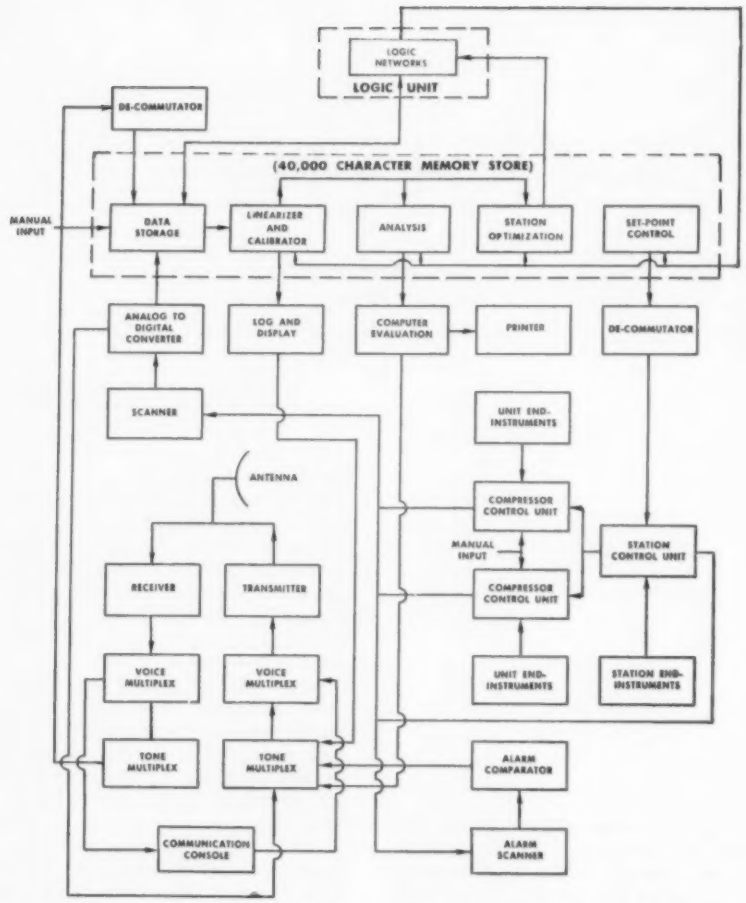


FIG. 5. Block diagram of slave station incremental computer and data processor.

Primary power failures will not endanger the computer operation because an emergency storage battery supply is used that is kept charged by the station primary power supply. Failure of the primary supply will allow operation until repairs can be made.

Maintenance personnel, through the station computer, can examine a station or compressor variable on demand at any time during routine or emergency maintenance.

After the station slave computer has determined the new unit operating characteristics, control signals are transmitted through the station controls to the unit controls. The unit controls directly monitor and regulate the variables associated with the individual compressors, but these variables are normally charged only upon direction from the station computer. Start-up and shut-down procedure for unit compressors is under the direct cognizance of the unit controller. Sequencing of the units is controlled by the station computer. Unit controls are permissive and assure that unit start-up and shut-down occur in a prescribed order at the proper time.

Station computers can be applied to facilitate preventive maintenance on station equipment. In other words the station computer can schedule preventive maintenance, calibration, alarm, and valve checks. The computer can produce, if desired, periodic reports on station equipment due, or overdue, for inspection, calibration, or overhaul. This scheduling function will occupy a relatively small portion of the station computer's memory.

Table 1 lists the station and unit conditions logged at the compressor station. Only the off limit and hourly condition is logged at the station. Required absolute values are available to maintenance personnel on demand. Current conditions are also displayed on the station control unit and the unit control console.

Station slave computers are easily integrated into an expanded line control system when extra stations are added. Therefore, no down-time of individual stations is required to integrate the full-scale station computer program into the 22 compressor station operation.

Certain indicators are provided to display instantaneous unit variables. These indicators are not integrated with the slave computer. They are meaningful in correlating logged and alarm variables, however.

Loss of unit control shuts down and bypasses the unit; however, loss of slave computer or data link will result in all units remaining on stream governed by unitized safety devices. In the worst case of simultaneous data link and slave computer malfunction, the station will normally operate at its last operational set-point.

Maintenance of the station slave computer is facilitated through the use of modularized, plug-in construction techniques. Solid state components such as transistors and highly reliable magnetic cores contribute to trouble-free, long-life operation. Semi-skilled maintenance personnel can be used for routine checks and maintenance.

The station computer is designed to operate continuously for six months without overhaul of the electromechanical or electronic components. ★ ★ ★

TABLE 1. Conditions logged at typical stations.

Condition	Angle-type station	Motor centrifugal station	All stations
Temperature			x
Lubricating oil			x
Pressure			x
Unit vibration			x
Bearing temperature			x
Jacket water temperature	x		
Engine speed	x		
Turbine speed	x		
Fuel gas pressure	x		
Exhaust temperature	x		
Engine stalls	x		
Compressor case temperature		x	
Motor overload		x	
Power outage		x	
Seal oil pressure		x	
Battery voltage			x
Control voltage			x
Power reverse phase		x	

Instrumentation, Controls, and Automation

Part 2: Telemetering

MAX T. NIGH

Final Delivery Relay Operation

Fig. 5 shows the final delivery relay operation achieved by operating a pushbutton. When the pushbutton is closed, the tone transmitter is turned on, impressing the tone on the wire line communication. The tone receiver responds to the presence of this particular tone and duplicates the office pushbutton operation at the field location by closing another pushbutton or its equivalent and turning on a lamp. When the office pushbutton is open the tone transmitter is not impressing the tone of a particular frequency on the wire line. The receiver is not sensing the presence of this tone and thus leaves its equivalent of the office pushbutton open.

Tone-Off Condition

In the upper part of the figure, the tone is off and the tone receiver is not energizing the receiver relay. This means no current is flowing through the receiver relay coil and thus cannot pick up the armature.

The relaxed finger is an indication of this no-current condition. Also note the contact on the relay is open in the circuit connecting the battery with the lamp.

Tone-On Condition

The bottom portion of Fig. 5 shows the tone on. The tone receiver relay has current flowing through the coil and the armature is pulled in due to the electromagnetic attraction of the coil for the armature. This is shown by means of the finger pushing in the armature. The contact in series with the battery and light is now closed, connecting the battery to the lamp and providing the indication.

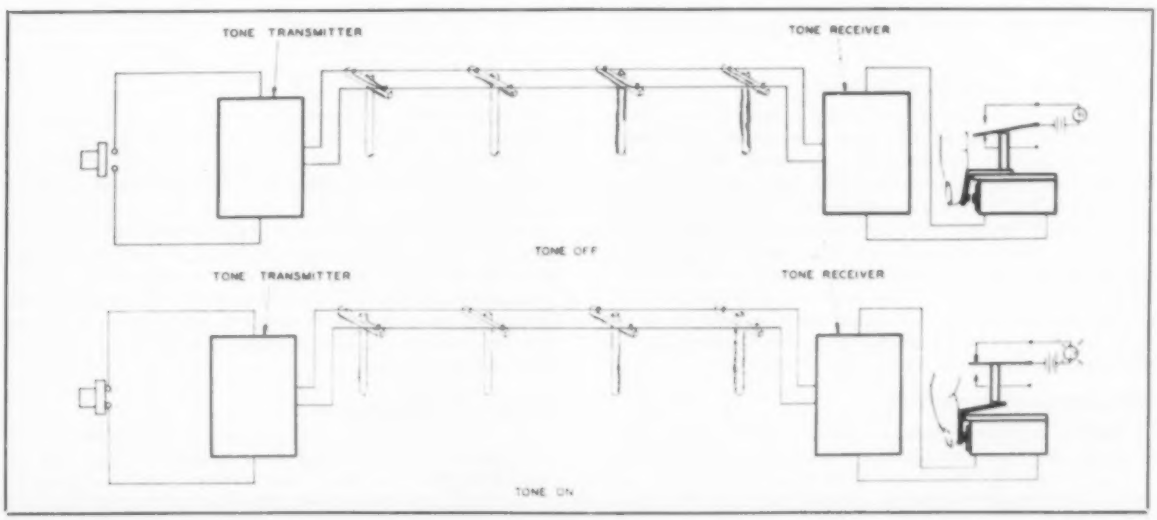
Types of Tone Equipment

This same process may be accomplished with any tone equipment be it AM (amplitude modulation) or FSK (frequency shift keying) tone equipment. The operation of closing a contact at one location is duplicated at another location by means of tone equipment in the case of wire line or microwave, leased or privately owned.

Recommendation for Further Study

It is not intended that the scope of this development of telemetering concepts include a complete discussion of the principles of communication equipment. To study these principles in more detail, the use of the Lenkurt "Demodulator" is recommended. This is a monthly publication of the Lenkurt Electric Company of San Carlos, California. Also recommended is the book, *Carrier Current Communications*, edited by J. N. Petrie and H. E. Clapham, published by Automatic Electric Company, 1033 West Van Buren Street, Chicago 7, Illinois. These publications have been designed to fill a need for simple, practical explanations of communications equipment and the considerations necessary for their successful use.

FIG. 5



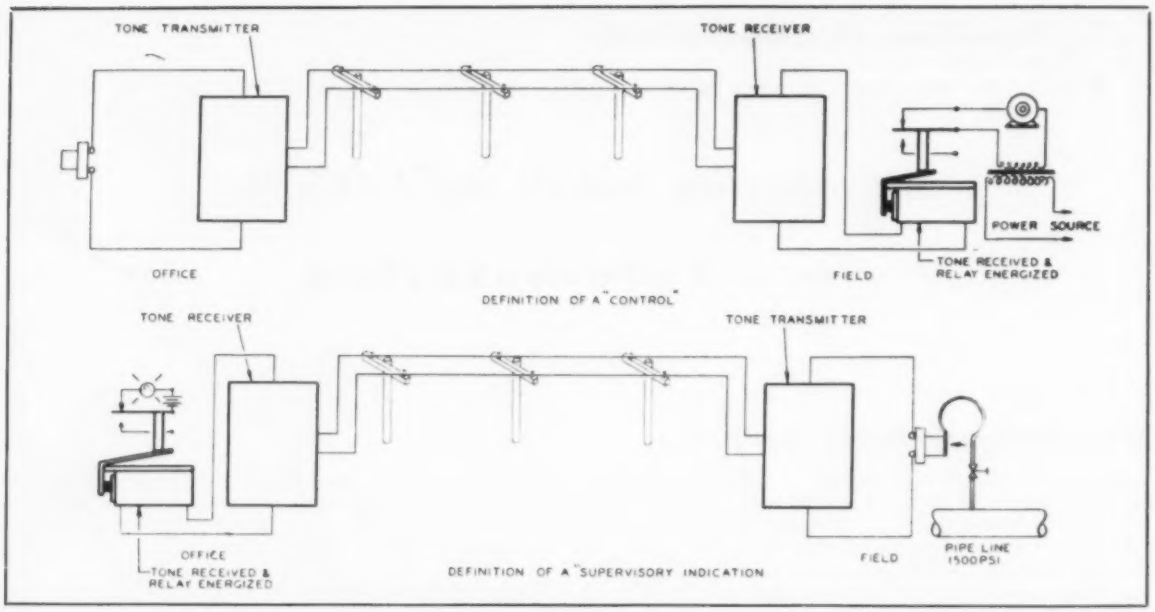


FIG. 6

Control and Supervisory Indication

Fig. 6 shows in graphic form the definition of a control and a supervisory indication. In some industries, control is called "contact operate" and supervision indication is referred to as "contact sense." On the left of the figure is the office or central control point, on the right of the figure is the field location, which could be anywhere from a few miles to a few hundred miles from the central office.

Control Defined

The upper portion of the figure defines a control in terms of pushing a button in the office and reproducing this closure at some distant point. In the above situation the pushbutton closure turns on a tone transmitter. This tone signal will be sensed by the receiver in the field, energizing its receive or repeat relay, closing contacts on this relay, which in this case would close the starting circuit for a motor. A sequence of events could also be started that would culminate in a motor or pump unit being placed in running condition on a pipeline, or turned off. This same control could request that information be transmitted back into the office for display.

Supervisory Indication Defined

In the lower portion of the figure, a supervisory indication is defined. In the field we have some contacts or "pushbuttons" that could be operated by pressure devices, temperature devices, limit switches, or some other measuring instrument. When such a measurement reaches a level that closes the pushbutton, it energizes a tone transmitter, the receiver in the office senses this signal and energizes this signal and energizes its repeat relay. Contacts on this relay then close the circuit from the battery to the lamp and result in the lamp being turned on. Thus the switch action in the field is duplicated in the office. Again the distance could be from a few miles to a few hundred miles.

Information Transmitted

Please note this does not tell us how much the pressure is unless we know the level at which the pressure switch was set to operate. We do not know how much higher than this level setting the pressure actually reached, but we do know it reached that level. Thus it is not telling us the quantity of any given measurement, but is telling us whether it has reached or passed some limit, be it high or low.

Engineering Alternates

This is an economical means for reproducing information from one point to another, if only a few signals are desired. Very few such systems are used because much more information is usually desired at a remote point. Pulsing a tone transmitter in a definite sequential pattern allows the transmission of information in a serial fashion with many indications being sent using one tone channel. This is costly in terms of the serial producing and receiving equipment, but saves on communication costs, a generally much more important cost. Sequence or programming equipment to generate and receive serial information will be discussed later.

Centralized Monitoring System

Fig. 7 is a block diagram of a centralized monitoring system as applied in the pipeline industry. This block diagram shows the office or centralized monitoring point on the left. In the middle circle is shown the means of communication, be it microwave or a wire line, voice channel or telegraph circuit. On the right is the field location. This is meant to represent many locations such as booster stations, delivery or take-off points, as well as regulating or metering stations.

If we follow control commands from the chief dispatcher through the pushbutton panel, through the information transmitter in the office, over the communications system, and into the information receiver in the field, we end in this command being duplicated at a field location and operating pipeline machinery. This pipeline machinery otherwise is under self-control.

Types of Information

At the field location we have two types of information we wish to send in for the office to use in monitoring the field location:

1. Yes or no type information . . . . has the pressure

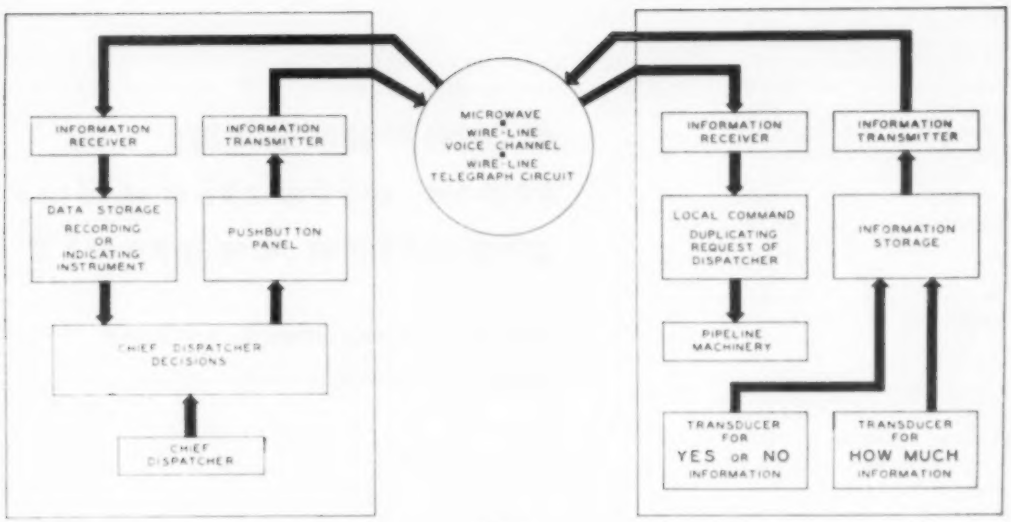


FIG. 7

reached a certain limit; is the flow less than or more than a certain amount; is the pumping unit on or off; is the gate valve open or closed; or what have you? This could be called digital information.

2. How much monitoring . . . . this "how much" information is the number of barrels or MCF per hour of flow; how many feet in inches and eighths are in the tank; what is the pressure in pounds per square inch? These are often referred to as analog measurements.

Use of Centralized Information

Both "Yes and No" and "How Much" types of information come into an information storage unit in the field, usually temporary storage, transmitted out over the information transmitter through the communications system, and is received in the office by an information receiver and stored in some form, either in relays, on charts, on digital indicators, or logged on a typewriter. This presentation of information permits the dispatcher to make decisions as to what should be done concerning the operation of the remote station. Many stations reporting in to one central point with much decision making required necessitates that this information be presented in as easily assimilable form as possible. This has brought on the use of logging systems, which present the data in typewritten form and eliminate the reading of many charts.

More important, a logging system provides the information in digital form—both Yes and No and How Much information. In digital form we have the information as ideal food for computers.

Proposed Control for Starting Unattended Motor

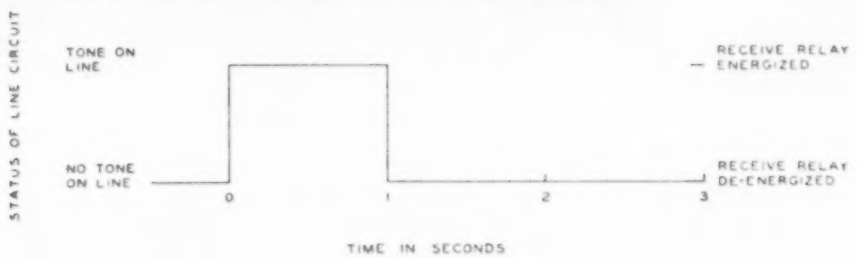


FIG. 8

Let's apply a tone system to starting a booster station remotely, in order to illustrate some of the engineering considerations that have to be made in setting up remote control, centralized monitoring, or data gathering systems. We might propose a method for remotely starting a pumping station on a pipeline using the control system described in Fig. 6. Such a proposed control could be set up using tone equipment on a two-wire communications circuit. We could design our circuits so that when we pushed the button in the office and turned the tone on, the receiver receiving this tone would close a contact on its receiver relay duplicating our pushbutton action in the central office. This could be used to start the pumping unit.

Graphical Representation Tone On and Off

We now need to use a graphical means of showing this pushbutton operation in order to reduce the amount of material required to describe operations. In Fig. 8 we show a level in the figure representing no tone on the line and a higher level representing a tone on the line. The horizontal axis is timed in seconds. This is a graphic means of showing the "modulation" of the tone transmitter and demodulation in the receiver.

By impressing this tone on for a period of one second, we could safely say this would be long enough to guarantee energizing the relay in the field. This would permit the starting of the pumping unit.

Using such a scheme presents some interesting problems. How reliable is it? Will it start the pumping unit when we want? Will it start it when we don't want it? The next figure will provide some answers.

To be continued

COMPUTERS: How effective for pipeline control?

What can a computer system do, how does it operate, what are the installation problems?

RAY G. MacINERNEY

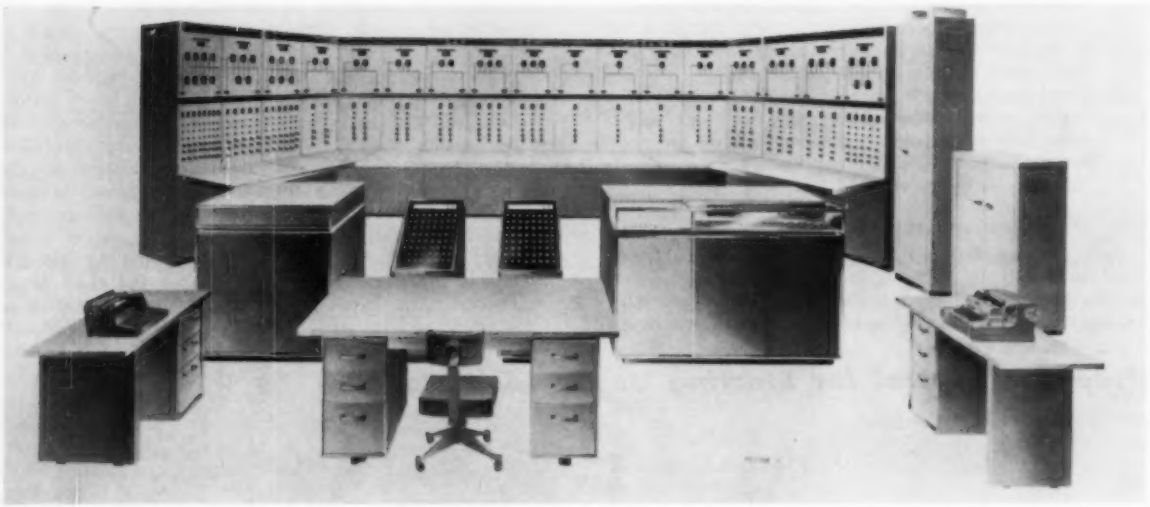


FIG. 1. Typical computer controlled dispatching center.

HOW CAN AN INDIVIDUAL process control computer be applied to a pipeline system to control its operation?

At the outset, let us make it clear that there is a difference between computers, or business data processors, utilized for off-line processing of data pertaining to the dispatching, accounting, or engineering design functions of pipeline operation and on-line, real-time, closed-loop control of the process by the computer alone without human assistance.

It is the latter type of system that I am going to describe, and for purposes of illustration a pipeline transporting natural gas has been selected, although the system can just as readily be applied to a liquid line.

Ray G. MacInerney sales engineer, Librascope Division of General Precision, Inc., Burbank, California.

Paper presented at Instrumentation Symposium, Texas A. & M. College, College Station, under the title "Pipeline Automation With Digital Computers."

Applicability to Pipelines

Currently, every industry is searching for new ways to improve productivity in face of the increase in competition, both quantitative and qualitative, from foreign producers, the rising rate of per capita consumption, and the diminishing percentage of suitable available labor in an expanding domestic population.

One of the most promising tools for alleviating this situation is the high speed electronic computer when it is incorporated into a completely closed loop control system. Some industries already have made installations of this type to control their processes more precisely.

The nature of the industry will determine its suitability for computer control. A few of the governing factors are: (a) What advances already have been made in the area of semi-automatic control; (b) how well the process dynamics are understood in mathematical terms; (c) the requirements for and availability of process phenomenon measuring devices and (d) background of the individual company in computer technology.

The pipeline industry measures up well to these criteria. Many companies presently are utilizing semi-automatic and remote control systems involving data transmission with wire lines or microwave. Thus, process dynamics of

transportation of liquids or gases can be fully expressed in mathematical terms compatible with a digital computer, and the different types of transducers necessary are already available, along with actuators and engine sequence controllers. Some companies already have installed computing systems for off-line data processing and computation work, but first-hand experience with a computer is not essential for a successful on-line control application.

How Control System Operates

The fundamental purpose of a pipeline is to transport gas or liquids over a long distance at the least possible cost. Sales contracts are written in such a way that this is usually achieved when the flow rates are maintained as close as possible to the maximum capacity of the line.

Therefore, the primary requirement of a control system is that it should maintain a high load factor consistently.

The physical properties of flow and the limitations in the strength of the material used in the pipe require that booster pumps, or compressor stations, be utilized at intervals along the line to augment the output of the primary station. Control of flow is achieved by manipulating the settings of many widely separated pumping units. Optimum control is achieved when, for a given flow rate and while meeting the load requirements assigned to it, each pumping unit is operating at its point of maximum efficiency, or minimum fuel consumption.

From this it can be seen that the ideal control system must have the ability to look at, or monitor, the operation of each compressor unit and valve on the system, decide what its optimum setting should be, not only with regard to its own performance characteristics but in relation to those of every other unit in the same station and at all other stations on the line, and finally to modify the set points of the actuators to implement required flow conditions.

Physically, these control functions can be achieved with a system comprised of: (1) Transducers and actuators located in the remote stations; (2) an electronic digital computer located at the dispatching center, and (3) a communications network, e.g., a microwave system, with associated terminal data converting equipment.

Fig. 1 gives an idea of what the computer control center, or dispatch center, looks like.

In the background is the station's annunciator, each panel of which corresponds to a specific compressor station and displays in colored lights and digital form operating data for each compressor unit, such as station suction and discharge pressures, ambient temperature, valve positions (open or closed), and compressor's condition, i.e., running or stopped.

It also contains switches and push buttons for manual control of each compressor unit in that station.

Immediately in front of the dispatcher's desk are two identical fault annunciators, which show in greater detail than the large panel could, the off-limit conditions, or alarms, for any station.

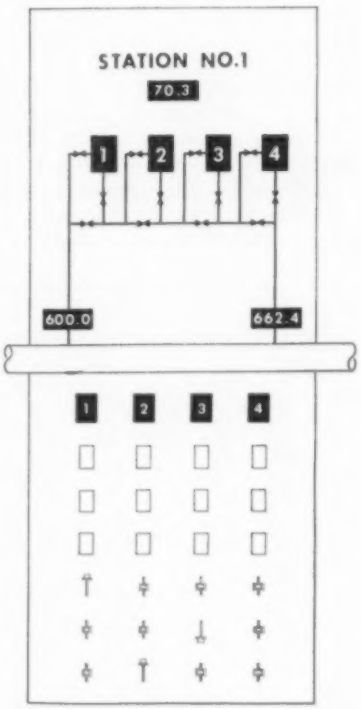


FIG. 2. Diagram of a typical control panel.

The final form of such a unit is limited only by a designer's imagination.

To the right is shown a Libratrol computer, with some of its controls and the optional digital clock display unit visible through the hinged transparent cover. To the left is a matching cabinet that will house additional input-output circuitry.

On the desk at the right is the main input-output unit. It consists of a punched-paper tape reader-punch unit and typewriter. By means of this unit, the programmer and operator instruct the computer what to do. Additional output printers, such as the typewriter on the desk at the left, can be supplied as required.

The tall cabinet at the right contains the microwave radio terminal equipment. The smaller cabinet contains terminal data converting equipment and is interposed between the computer and the microwave transmitter-receiver units.

Fig. 2 suggests what form a typical control panel could take.

At each station and compressor unit, hardware will be installed to measure and modulate the phenomena that are to be controlled to detect off-normal operating conditions, and to communicate with the computer. The remote equipment will be constructed on a modular basis and, so far as is possible, identical or similar components will be used in each station and for each compressor unit, so that servicing will consist primarily of component replacement.

The control system's mode of operation is determined by its program as specified by the pipeline owner. It will vary from one pipeline to another.

In its normal mode of operation, the gas transmission system will be under the control of the computer located remotely from the pipeline at the computer control center in the dispatcher's office. It will effect control by initiating electrical signals that will modify the set-points of all the compressor units to optimize the throughput and minimize the fuel and power consumptions. The dispatcher will supervise the operation and stand by to assume manual control, if necessary.

More specifically, the computer periodically will scan the operating parameters of every station and each compressor unit in that station, store the data in its memory, and display some of it on the control panel. At various intervals it will make the following computations:

1. Supercompressibility
2. Transportation cost
3. Line material balance
4. Line efficiency
5. Scan off-normal transducers to protect pipe and compressors against overpressure and other unsafe conditions
6. Station's computation as required upon change of throughput or on demand by the dispatcher

Upon completion of the station's computation, the computer will modify

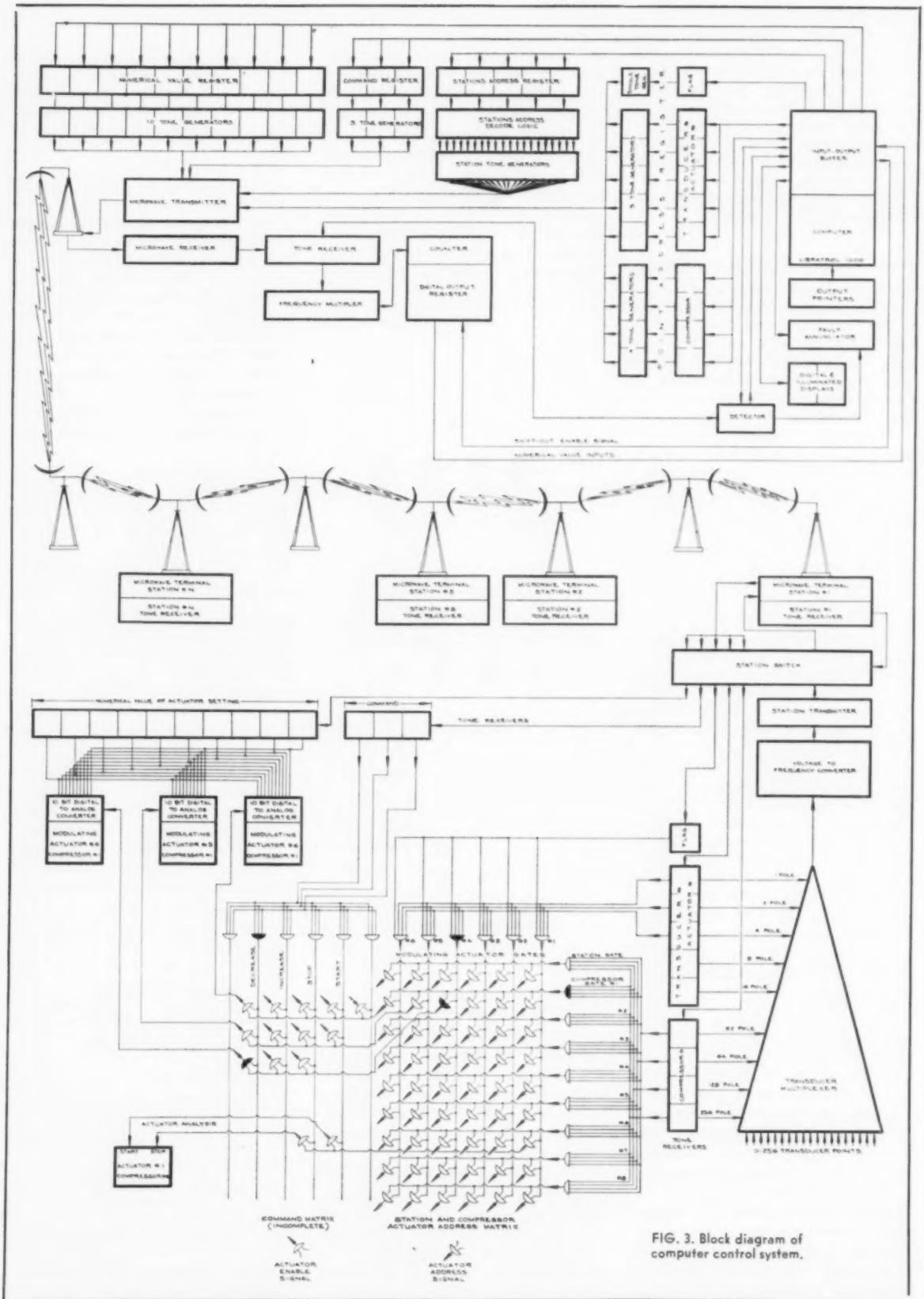


FIG. 3. Block diagram of computer control system.

the set-points of the compressors' controllers to the new values, if any, unless prevented from doing so by the dispatcher.

If upon failure of a compressor or other first or second order fault, a spare compressor is not available in the same station, the station's computation will be computed for these new conditions until the faulty compressor unit has been restored to operating order. The faults will be displayed on the fault annunciator panel.

The method of alerting the appropriate maintenance depot regarding station faults presents an opportunity for exercising ingenuity. A printer can be placed at each depot, along with annunciator panels that indicate running conditions, accumulate total engine hours, schedule overhauls, etc. One of the possibilities here is that the detection devices would be set to enable the system to give advance warning of compressor failures, enabling repairs to be scheduled in the most convenient manner. Regarding the overall control system layout, the function of the hardware is to enable the computer to communicate with, or address, each individual actuator or transducer. The system design will fall into two main divisions: (1) The computer control center, and (2) the remote stations. Regarding the latter, the hypothetical pipeline system we are using as an illustration will have a relatively large number of compressor stations, each with one to eight compressor units of different types, but with essentially the same number of transducer and actuator points associated with each compressor. Approximately the same number of similar transducer and actuator points will be associated with each station. Each point will then have a point address number consisting of its station, compressor and transducer or actuator numbers, plus a flag number to differentiate between transducer and actuator. For station actuators or transducers the compressor number will be zero.

The point address logic is identical for all stations up to the maximum quantitative requirements of any station. Provision has been made in this design for a maximum expansion up to 32 stations, 15 compressor units per station, 32 transducer or actuator points per compressor and station, 8 command per compressor and station, and ten-bit or 4 decimal digit precision for actuator setting.

This capacity is more than adequate for maximum anticipated requirements, but it can be extended, if required.

Fig. 3 shows the layout of the data handling system from the computer to the remote transducers and actuators. The diagram follows roughly the shape of the letter "S." In the top right hand corner is shown the computer with the data display units. Across the upper part of the drawing are the special output registers and tone frequency generators that feed into the communications network. At the bottom is shown a schematic of the data receiving-and-gathering logic for a typical remote pumping station.

By time-sharing some components, and by designing them on a modular basis, it has been possible to minimize the equipment in the remote stations. As the purpose of the station hardware is to enable the computer to communicate with the compressor units, each actuator and transducer has its own specific address and can be addressed in any combination of sequences, or even at random, by the computer, or its programmer. No physical components are required for sequencing the computer from one unit to another so that no problems with synchronization or difficulties arising from the system getting out of step can occur, and all changes in the operation or programming can be made from the computer control center without modifying any hardware.

In operation, the computer addresses a transducer by shifting its address, composed of its station number, compressor number, and transducer number, into the assigned registers at the control center and setting the flag register at zero. This data is converted into tone frequencies, which are introduced into the microwave network. The tuned receiver in the station addressed responds (and closes the station switch), enabling contact to be made with that station only. Thus, the transducer number and compressor number are set up in the corresponding register in the station. The transducer then transmits its value through the microwave network to the computer, which has been programmed to receive it. If the computer decides to modify an actuator, it sets the flag register to a "one," shifts a command, e.g., start, stop or increase,

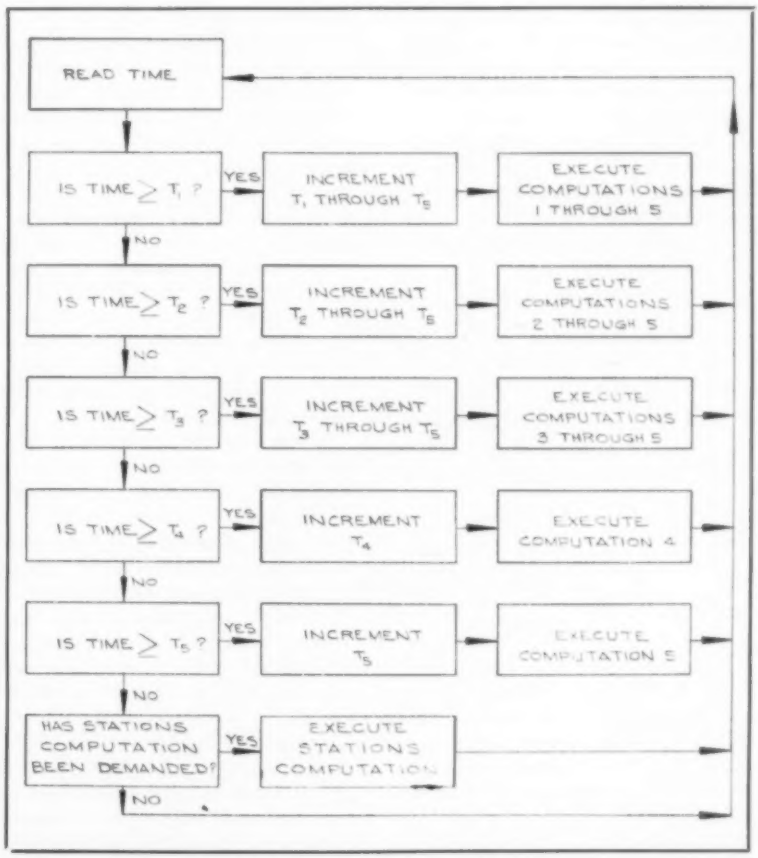


FIG. 4. Time-box program.

decrease, into the command register, and the value of variation, if any, into the numerical value register, and then the actuator with the same address number as the original transducer will be correspondingly modified.

Setting the flag back to zero enables the computer to scan the transducer and see whether the command has been carried out. In this way, closed loop control of all process actuators is obtained. For reading large numbers of off-normal transducers, time can be saved by switching all stations onto the line simultaneously, thereby scanning all corresponding points concurrently. If an off-normal condition is detected, the computer will branch and locate the faulty point while setting off alarm lights on the fault annunciator in front of the dispatcher's desk. The order of the fault, which the computer can evaluate, will determine what it does next, e.g., start up standby units, or recompute the station's computation. All of this is under the control of the program and can be modified if, or when, necessary.

Fig. 4 shows a time-box program that might be used for scheduling the different computation program routines tabulated below. The time-box program enables the computer, through its digital clock, to keep track of time and to perform all of the computation routines at the following intervals timed from some time zero. During the intervals shown, some, but not all, of the computations will fall due at the same times. The time-box routine will also sort out priorities and insure that intolerable delays do not occur.

Program	Time interval, min	Computation
No. 1	1440	Supercompressibility
No. 2	60	Gas transportation cost
No. 3	30	Line material balance
No. 4	15	Line efficiency
No. 5	2	Scan all off-normal type transducers
No. 6	Random	Station's computation

This assumes all programs are timed from an arbitrary time zero, and a memory register is allocated for each that is incremented by its time interval each time the computation is performed. The station's computation will more than likely take longer than two minutes, so it will have to be broken up and fitted into the time-box program whenever there is time available for it.

It should be emphasized that each program in the above tabulation is performed *at* the time interval indicated. For example, program No. 1 is performed every 1440 minutes; the computer does *not* take 1440 minutes to perform the program.

Computer Effect On Pipeline Design

Use of a computer to control a gas pipeline can influence its design. A greater number of stations spaced more closely together and operating at lower compression ratios have a significantly lower horsepower requirement than fewer stations with large numbers of compressors widely separated along the line. With computer control, compressors can be spaced widely, as men are not required for their operation, and design of the station can be made without regard to limitations imposed by personnel on working conditions, housing, and logistics. Furthermore, at lower compression ratios advantage can be taken of the characteristics of centrifugal compressors, which produce an increase in efficiency with reduction in compression ratio.

Two interrelated mandatory requirements must be met if optimum utilization is to be derived from a computer control system. First, the design of the system must be such that its operation can be changed readily after installation without replacement of hardware components. No initial program written for a process problem will escape the modifications and improvements that will be devised by the operating people as they gain experience with and confidence in the computer control system. For this reason we advocate strongly the general purpose type stored program digital computer.

In the Libratrol system that I have just described the function of all the remote hardware, with the exception of the engine sequence controllers, is solely that of enabling the computer to address discretely all the process phenomenon sensing and actuating devices. What the computer does as a consequence of connection with any device is under the control of the program stored in its memory and therefore can be modified readily.

The second requirement for implementing a successful computer control system is that its development must be a joint effort on the part of the process owner and the system manufacturer. The manufacturer can provide hardware know-how and the process owner obviously knows more about his own process than anyone else. In combination, individuals of the two companies will develop all the information necessary to specify the system components, and while doing so will of necessity come to learn a great deal of each others specializations. Although it is likely that the technical people involved may have mutually inclusive backgrounds, this is *not* essential. But it is important that, as the date of installation approaches, the process owner's people be fully conversant with the workings of the system — in particular, that they fully understand the program. This can best be achieved if they have written it themselves — under the direction of the manufacturer's programmers, if necessary. They are then in a position to take full advantage of the flexibility built into the system by its designers by constantly re-evaluating its performance and modifying the program where expedient.

It has been stated that in the minds of most pipeliners the primary question regarding applying computer control is not if, but when. The answer to this is: Just as soon as a payout can be established, for, as I have already said, the process dynamics of pipelines can readily be written in the mathematical language of the computer.

In conclusion, the question of how to go about getting a computer control system is worth a few words here. Some process owners, having got a bidders' list together and drawn up a set of system specifications, have asked for prices. Many manufacturers then spend considerable time and money in preparing proposals and price quotations, which, upon review, are found not to be quite what is required. A second go-around is initiated and, if after that, the process owner decides to go ahead with the installation, he may still be uncertain of what he is getting because he could not possibly have allocated the time to work in detail with all the suppliers, nor could they, as they are busily engaged doing the same thing for other process owners.

Therefore, it behooves the process owner to select his computer control system manufacturer early in the proceedings and stick with that one all the way through, spending considerable time, as will be necessary, in planning, evaluation, and system design. Only by means of such a thoroughgoing joint effort can a successful system be realized. ★ ★ ★

LAUNCHER IS KEY TO NEW AUTOMATIC PURGING TECHNIQUE

KEY TO A NEW AUTOMATIC purging technique for single and multi-size gas pipelines is a launching system embodying a special modification of the Rockwell Hypresphere valve. The only manual operation involved is the return of rubber spheroids from the receiver to the launchers.

By means of the spheroids liquid is removed from low spots in the line without the need for drips, thereby increasing efficiency and reducing the power required to move the gas.

The launching system is operated in this manner:

Inflated neoprene spheroids are stacked on an incline against the valve, which is similar to other Hypresphere valves but has one end of the port through the plug closed off to create a pocket. The bottom spheroid in the stack rolls into the pocket, ready to be launched. When the valve is turned 180 deg the ball is swung around and out to drop into the pipeline where it is propelled by line pressure.

In multi-size lines, launchers are placed at each point of line size change. When a 16-in. spheroid approaches the point where the line increases to 18 in., a signal is tripped that operates the valve, dropping an 18-in. ball right behind the smaller one. The bigger ball trips another signal (which the smaller one didn't touch) turning the valve back to its original position. Another spheroid drops into the pocket, and the launcher is ready for the next purging cycle.

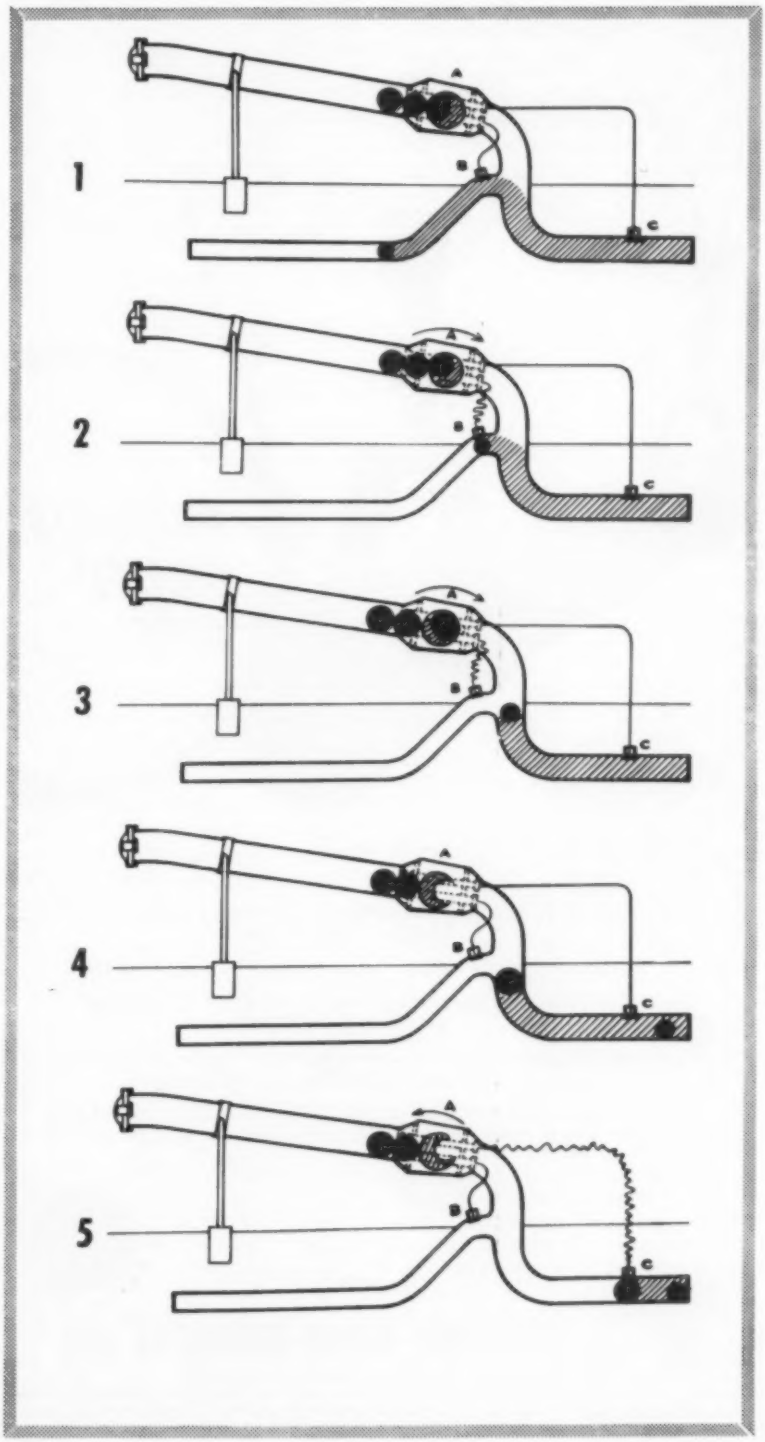
Because the valve, being closed at one end, provides a positive seal against the gas at all times, it must hold against full line differential but it need not operate against it. The valve is operated by the line pressure through 4-cylinder hydraulic operators.

The Hypresphere is a spherical-type valve containing four main parts: The operating stem, the ball plug, two spherical ring seats, and the body housing. Only the operating stem and ball plug move. The valve operates on a rotating principle and opens and closes with an easy quarter turn.

The system has only one receiver—at the end of the line. The balls are allowed to pile up in the receiver barrel, while a rising gas line carries the gas into the main gathering system, leaving the liquid to go into the liquid storage area. A standard 90-deg rotating Hypresphere valve provides positive shut-off of the gas while the balls are unloaded for return to the launchers.

Colorado Interstate Gas Company, which pioneered the new purging system, reports that flow efficiency has been greatly increased and the problem of pressure build-up, which they'd had, was eliminated.

The company has had liquid recovery as high as 650,000 gal in six weeks.



"Temporary" Granted For CIG's Rawlins Station

Colorado Interstate Gas Company has received temporary authorization from the Federal Power Commission to build its proposed 4500-hp Rawlins compressor station, which will be used next winter under the temporary proposal to provide increased service to customers in the Rocky Mountain area.

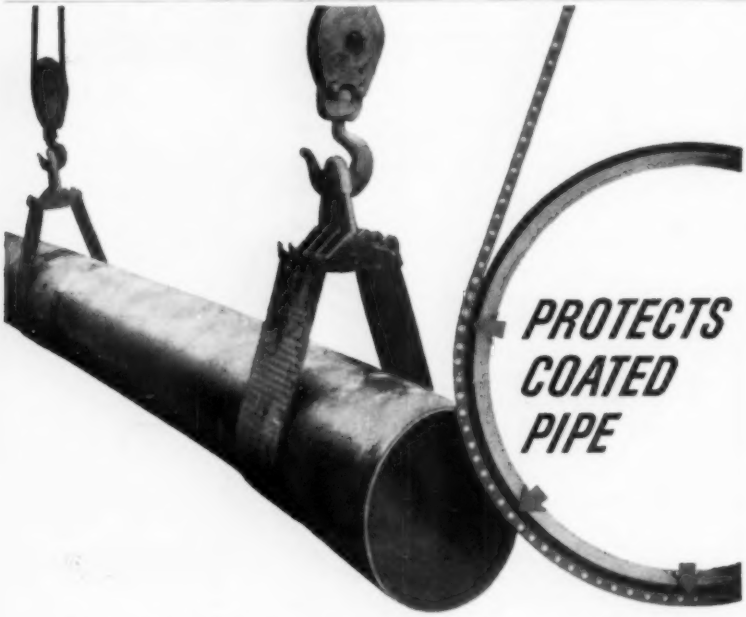
The $1,751,927 station is part of the company's larger project to sell large volumes of gas to El Paso Natural Gas Company for resale in California.

The FPC conditioned the temporary authority to require that, in the event it denies the overall expansion of Colorado Interstate, the cost of the station will be eliminated from CIG's rate basis unless the company can show that its continued operation is in the public interest.

Plans Arkansas Gathering Lines

Arkansas Western Gas Company is planning to tap new natural gas reserves in Arkansas' Coal Hill, Altus, and Rock Creek fields with $298,770 worth of new pipelines.

The company has asked the state Public Service Commission for permission to build the facilities in Johnson and Franklin counties.



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Pipeline

To Start $93,000,000 B. C. Project

Gas Trunk Line of British Columbia Limited has announced the beginning of construction on the first phase of a $93,000,000 natural gas pipeline system in northeastern British Columbia.

Scheduled for completion in December, 1961, the 30-in. line will extend 245 miles southward from Fort Nelson to connect with the existing Westcoast Transmission pipeline near Chetwynd, which presently serves southern British Columbia markets and exports surplus Canadian gas to the El Paso Natural Gas Company system extending through the western United States.

Gas Trunk Line will be able to increase its initial capacity of 350,000,000 cu ft per day to 650,000,000 cu ft with additional compression.

Deliveries to Westcoast will necessitate expansion of that system. Two additional compressor stations costing approximately $25,000,000 will be built within the year to raise Westcoast's capacity to 660,000,000 cu ft per day, and engineering plans have been made to loop the Westcoast system in the near future and double its volume to more than one billion cu ft.

First phase of the Gas Trunk Line construction, to be completed this year, includes $11,000,000 worth of extension pipelines at the southern end of the route. One, approximately 55 miles long, will extend into the Nig Creek, Laprise, and East Laprise fields of B. C. Another, 30 miles long, will extend to the B. C.-Alberta boundary and transport gas from B. C.'s Boundary Lake field and be available to serve the adjoining areas of Alberta, where the Floral and Worsley fields are situated.

Pipelaying on the main system will begin in the spring.

Gas Trunk Line will be owned by producing companies presently active in the Fort Nelson area. Pacific Petroleums Limited, which sponsored the Westcoast pipeline, is sponsor of the Gas Trunk Line project.

The new Gas Trunk Line is part of a major pipeline construction and petroleum development program now under way in British Columbia which will result in the expenditure of some $225,000,000. Construction of the Alberta Natural Gas Company Limited pipeline through southeastern B. C. is now under way at a cost of approximately $40,000,000, and Trans-Prairie Pipelines Limited is beginning an oil pipeline in northeastern B. C. *(see related story, this issue).*

Projects

PG&E Permit Spurs Canadians to Action

Alberta companies have started rolling with the calling of tenders on their portion of the large-scale export of southern Alberta natural gas to California. The action followed the California Public Utilities Commission's authorization to Pacific Gas & Electric Company for the construction of the most southerly stage of the project for export of 414,000,000 cu ft of gas per day. Related to and affiliated with this project is a smaller project for export of 140,000,000 cu ft per day to the Pacific Northwest states. The two movements of gas will share the same system as far as the Canadian border.

Alberta Gas Trunk Line Company Limited and Alberta Natural Gas Company will work on final surveys this fall. Contractors will go ahead with right-of-way clearing and grading and probably some pipe stringing, but pipelaying will not start until next spring. Riprapping, where necessary, can be done through the winter.

Pipe orders have been placed on tender. It is expected that preference will be given to local pipe mills. Two big-inch mills in Alberta, both of which can roll pipe within the size range from 16 to 36-in., were completed this summer.

The Alberta Gas Trunk Line system, costing an estimated $110,000,000, will traverse much muskeg and swamp terrain and require extensive rock drilling. The company will start the northern portion with 55 miles of 26-in., from Berland River to the junction with a lateral from the Lovett River field. There the line will telescope into 75 miles of 30-in., which goes as far as the cross-over point near Buck Lake where a lateral will tie in to the existing plains system also operated by Trunk Line. The largest portion of the main line will be 256 miles of 36-in. from crossover point to southern terminus.

Trunk Line, at the northern end, will build a 37-mile, 18-in. lateral to bring gas from Kaybob field; a 34-mile, 12-in. Lovett River lateral; and a 36-mile, 12-in. Stolberg lateral. A composite lateral, 23 miles of 24-in. and 33 miles of 20-in., will form the crossover to the Westerose South field, farthest north point on the plains system at present. Two short laterals, 9 miles of 10-in. and 14 miles of 12-in., will tie in the Wildcat Hills and Crossfield fields. East Calgary will take 17 miles of 16-in. Savanna Creek will require the longest – 43 miles of 20-in. The Montana delivery lateral will be 66 miles of 16-in. and include the Waterton Park gathering lateral. This totals a lateral network of 312 miles.

A 108-mile, 36-in. British Columbia export line costing about $40,000,000 — to be owned and operated by the PG&E subsidiary, Alberta Natural Gas Company, with some public participation and a share to Westcoast Transmission Company Limited — will require extensive rock drilling and shooting.

"Temporaries" On Highland, St. Peter-Elgin Projects

The Federal Power Commission has granted Northern Natural Gas Company temporary authorization to add 4000 compressor horsepower, about 21 miles of small diameter pipeline, and a measuring station to enable it to withdraw 100,000,000 cu ft of natural gas daily from the St. Peter-Elgin portion of the Redfield storage area in Iowa. Cost of construction is estimated at $1,439,200.

Northern also, under temporary authority, will increase the St. Peter-Elgin storage inventory to a maximum of 40 billion cu ft.

Northern's Highland gathering system proposal also received temporary authorization. Costing $1,550,700, it involves about 40 miles of various diameter pipeline, 48 well measuring stations, and a dehydration and hydrocarbon extraction plant having a capacity of 50,000,000 cu ft of gas daily. This system will take natural gas purchased in Laverne field, Beaver County, Oklahoma.

Line To Move Offshore Oil

Work is scheduled to start November 1 on a $950,000 crude oil pipeline that will span Louisiana bayous, swamps, and marshlands.

The new 21-mile, 8-in. pipeline of Continental Pipe Line Company will connect with The Texas Pipe Line Company's line at Golden Meadow, Louisiana, and enable crude from Grand Isle offshore fields to move westward to key refining centers including Lake Charles, Louisiana, and Port Arthur, Texas.

Completion is expected by February 1, 1961.

Gathering System in Texas

This fall Lone Star Gas Company will install a new natural gas gathering pipeline system in Runnels County, Texas, to aid in supplementing present supply for the Ballinger and San Angelo areas this winter.

Requiring approximately 9 miles of 6-in. pipeline, the system will connect present Humble Oil and Refining Company wells in the Southwest Winters field.

Plan to Pipe B. C. Oil Okayed

Trans-Prairie Pipelines Limited has received a permit to build a 144-mile crude oil pipeline in British Columbia and plans to proceed with construction during the winter, aiming for completion of the southern portion of the system during 1960.

Including 115 miles of 4 through 8-in. main line and 29 miles of 6-in. lateral, the $5,000,000 pipeline will start at Milligan Creek field, take in Milligan as well as Beatton River field, pick up Boundary Lake field oil through the lateral, and terminate at Dawson Creek, with a takeoff point at the Fort St. John refinery on the way.

A certificate for a similar line was granted earlier to Peace River Oil Pipe Line (B. C.) Limited — one of four original applicants with Trans-Prairie — but this company surrendered its permit (see *Pipeline Engineer*, September, 1960).

Products Line Planned Along Lake Michigan

Ten major oil companies have revealed plans to build a $19,000,000, 200-mile, 16-in. products pipeline from refineries at the foot of Lake Michigan to Milwaukee and the Fox River Valley cities of Wisconsin.

Paralleling west shore of the lake and ending at Green Bay, Wisconsin, the line, with a capacity of 150,000 to 175,000 bbl per day, could eventually replace tanker fleets that for many years have moved products on Lake Michigan.

Companies intending to participate in the venture are: Clark Oil & Refining Company; Pate Division, Humble Oil & Refining Company; Standard Oil of Indiana; Shell Oil Company; Continental Oil Company; Ohio Oil Company; Pure Oil Company; Mobil Oil Company; Texaco, Inc.; and Cities Service Oil Company.

FPC Adopts Examiner's OK On $40,668,000 Expansion

The Federal Power Commission has adopted an examiner's decision authorizing Texas Eastern Transmission Corporation to fully institute its new winter service program calling for deliveries of approximately 20 billion ft of gas annually.

The order allows Texas Eastern to develop its share of underground natural gas storage capacity at Leidy and Tamarack in north central Pennsylvania and construct and operate about 215 miles of various diameter pipeline, a new 3300-hp compressor station at Perulack, Pennsylvania, and additional metering and regulating stations, at a total cost of $40,668,000.

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D-46

Michigan Wisconsin Gets FPC "Green Light"

Michigan Wisconsin Pipe Line Company's $44,876,000 expansion involving construction of about 567 miles of pipeline and 6000 additional horsepower in compressor capacity has received Federal Power Commission authorization.

The company, to increase its average daily sales capacity by approximately 100,000,000 cu ft of natural gas drawn from Laverne field, Harper County, Oklahoma, will proceed to build approximately 342 miles of 24-in. pipeline paralleling its main line between stations in Kansas and Illinois, plus about 188 miles of 30-in. paralleling the existing system between stations in Michigan, and approximately 37 miles of small diameter loops on existing market lines in Wisconsin. Two Kansas compressor stations will get the additional horsepower.

INTERNATIONALLY...

Producers Pipelines Limited anticipates a further 20 miles of extension line will have to be built this fall to provide for pipeline needs of current development drilling in the southeast Saskatchewan area of Canada. Banister Construction Company Limited has just completed extending gathering systems for the company in the Midale, Arlington-Manor, Benson-Viewfield, Cantal, Hastings, Alameda, Oxbow, Glen Ewen, Pinto, Queensdale, and Steelman fields.

Pakistan is studying the economic feasibility of a 1000-mile pipeline network to supply northern Pakistan with Sui gas. The Burmah Oil Company Limited has submitted a project report to the president, ministers, and planning commission.

Russia plans to tap its Ust-Vilyuisk gas field in northeastern Siberia with a 250-mile pipeline running over permanently frozen ground to the frontier cities of Yakutsk and Pokrovsk.

A sub-arctic Canadian northwest SAC base expansion will set off a pipeline expansion by Cold Lake Pipe Line Company, Ltd., to meet additional natural gas heating requirements of the 4400-sq-mile installation where temperatures plunge to levels that freeze heating oils. The company, now supplying 1,500,000 cu ft daily to the Cold Lake Royal Canadian Air Force base and missile testing range, will extend an additional 225 miles to Edmonton —bringing natural gas to 83 isolated bush settlements along the route and boosting daily deliveries to the base to 3,500,000 cu ft.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

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permits higher horsepower, higher tip speeds, greater design flexibility

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Produced by a special welding process developed by De Laval, this new welded wheel construction permits higher tip speeds and fewer stages for a given pressure ratio.

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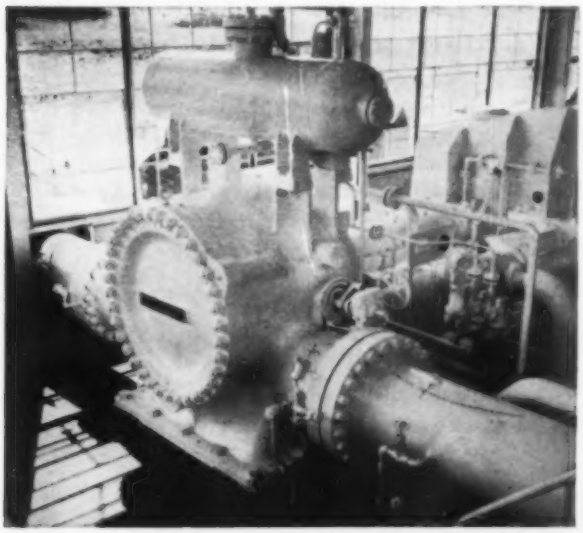

Rated at 20,000 horsepower, this compressor, on stream for a prominent pipeline company, develops a pressure ratio of 1.56 in a single wheel, pumping 800,000 standard cubic feet per day at an inlet pressure of 652 psia and an outlet pressure of 1020 psia.

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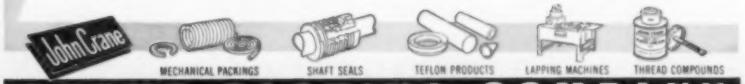
Request Bulletin S-215-1. Give mechanical and service details for specific recommendations.

Crane Packing Company, 6400 Oakton Street, Morton Grove, Illinois (Chicago Suburb)

In Canada: Crane Packing Company, Ltd., Hamilton, Ont.



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"Engineer, builder, industrialist and leader of broad vision in large construction undertakings, nationally and internationally — a pioneer in the creation and development of the modern construction industry, which is unequaled throughout the world and which has made possible the preeminence of our country in time of war and in time of peace."

This is the citation granting to **Stephen D. Bechtel,** president of Bechtel Corporation, the 1961 John Fritz Medal which is awarded annually for notable scientific or industrial achievement in the engineering profession. It is sponsored by the American Society of Civil Engineers, American Institute of Mining Engineers, The American Society of Mechanical Engineers, American Institute of Electrical Engineers, and American Institute of Chemical Engineers. Bechtel also has been announced as the person *"whose achievement contributed most to the effectiveness of the transportation industry in support of national security"* and chosen to receive the eleventh annual National Transportation Award to be formally presented during the association's annual convention, October 2-5 in New Orleans, Louisiana.

▸ **Interprovincial Pipe Line Company** has appointed **John Blight** treasurer, succeeding **D. G. Waldon,** now assistant general manager. Blight moves up from chief accountant at the company's Edmonton office and assumes his new duties at the company's executive office in Toronto.

▸ **Charles M. Hunter,** assistant general superintendent of Southern Natural Gas Company, has been promoted to general superintendent.

▸ **Norman V. Kinsey, Jr.,** has been elected a director of Transcontinental Gas Pipe Line Corporation succeeding his father, the late Norman V. Kinsey, who was a member of the original board of directors of the company. Kinsey was associated with his father in the firm of Kinsey and Kinsey in all phases of the oil, gas, and pipeline business and was active in the formation and building of Transcontinental Gas Pipe Line, Texas Illinois Natural Gas Pipe Line, and Pacific Northwest Gas Pipe Line.

▸ **United Gas Corporation** announces the election of **James A. Elkins, Jr.,** of Houston, Texas, and **J. Finley McRae** of Mobile, Alabama, to its board of directors.

PERSONALS

P. H. Swinchatt, vice president of Shell Pipe Line Corporation and assistant to the president of Shell Oil Company, will retire December 31, 1960, after nearly 40 years' service with Shell. **E. A. Hugill, Jr.,** currently corporate secretary, will succeed him, combining his new administrative duties with his present responsibilities.

Great Northern Railway has elected H. G. Nilles, the railway's attorney for North Dakota, to the directorate of the Great Northern Pipeline Company, a wholly-owned subsidiary which will operate a 110-mile crude oil pipeline to be built by the railway in that state.

Texas Eastern Transmission Corporation has promoted **Robert M. Jones, Jr.,** from general office dispatcher to assistant chief dispatcher.

Kansas-Nebraska Natural Gas Company's new public relations director is **J. Theodore "Ted" Kennedy.** He replaces **James J. Diesing** who has accepted a position with Northern Natural Gas Company.

Joining Transwestern Pipeline Company as section foreman in Mountainair, New Mexico, is **R. D. Hammett,** formerly station operator with Texas Eastern Transmission Corporation in Lafayette, Indiana.

O. B. Denny, assistant district superintendent in Interstate Oil Pipe Line Company's Raceland, Louisiana, district, is on loan to Esso Libya as chief inspector on construction of the company's new Libyan crude oil line. **Dee McKinley,** operations engineer for Interstate, succeeds Denny.

New administrative vice president and coordinator of transportation of Gulf Oil Corporation is **H. B. Brown.** Brown, a 10-year veteran with Gulf, succeeds **R. D. McGranahan** who recently resigned to become president of Wilshire Oil Company of California.

F. C. Lantz has retired from active business and resigned from the board of directors of Producers Pipelines Limited and its subsidiary, Westspur Pipe Line Company. At the time of his retirement he was general manager of the transportation and supply department of Imperial Oil Limited.

Appointed new director of measurement research for Transcontinental Gas Pipe Line Corporation is **E. N. Armstrong,** formerly superintendent of measurement and an active participant in short course work, particularly the Southwestern Gas Measurement Short Course at the University of Oklahoma. **W. W. Cofield,** who has been serving as assistant superintendent in Transco's measurement department, succeeds Armstrong as superintendent.

C. Milton Allen, Trunkline Gas Company's controller and assistant secretary, has been elected president of the Houston Control of the Controllers Institute of America; and **James T. Noel,** Panhandle Eastern Pipe Line Company's assistant controller, is new president of the Kansas City Control.

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WITH THE PIPELINE CONTRACTORS

● **Banister Construction Co. Ltd., 625 Northern Hardware Bldg., Edmonton, Alberta, Canada.**

Producers Pipelines, Ltd. — undetermined amount of 3, 4, and 6-in. crude oil gathering system in the Estevan, Saskatchewan, area. Field superintendent: Basil Seemann. Foremen: Steve Slade, D. Gooderick, Joe Schmidt.

● **Bechtel Corp., 220 Bush St., San Francisco 4, California.**

Michigan Wisconsin Pipe Line Co.—84 miles of 24-in. between the Mississippi River and Sandwich, Illinois; approximately 47 miles of 30-in. in Lake, Porter, and La Porte counties, Indiana; and approximately 14 miles in Berrien County, Michigan.

Esso Standard (Libya) Inc.—a 100-mile, 30-in. crude oil pipeline from the Zelten field in Libya, north to Marsa el Brega on the Gulf of Sirte.

● **Collins Construction Co., Box 86, Port Lavaca, Texas.**

Petroleos Mexicanos — dual 12 and 24-in. natural gas pipeline river crossings between Pemex City and Mexico City, Mexico. Tom Broom is supervising.

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● **Sam Carline, Inc., Box 138, Berwick, Louisiana.**

Shell Oil Co. — 4 to 6-in. offshore gathering from Block 18 to Eugene Island, Louisiana. Warren Stockstill is supervising.

Texaco, Inc.—a 3-in. line from Tiger Shoal field to offshore Iberia Parish, Louisiana.

Texas Gas Transmission Corp. —a 12-in. crossing of the Atchafalaya River 3 miles north of Baldwin, Louisiana.

● **O. R. Burden Construction Corp., Box 5216, Tulsa, Oklahoma.**

Natural Gas Pipeline Co. of America—58 miles of 36-in. in the vicinity of Concordia and Ford, Kansas. R. M. Jones is supervising. Field office: Glasco, Kansas.

Peoples Gulf Coast Natural Gas Pipeline Co. — 37 miles of 30-ni. in Wharton, Ft. Bend, and Harris counties, Texas.

● **W. E. Claycomb and Son, Rt. 1, Cody, Wyoming.**

Husky Pipeline Co. — a 96-mile line from Husky Oil Company's refinery at Cody, Wyoming, to a connection with Yellowstone Pipe Line at Billings, Montana.

● **D. Michael Curran & Co., Eklund Bldg. Great Falls, Montana.**

Cenex Pipeline Co.—a 190-mile, 8-in. products pipeline in Montana and North Dakota. This is a joint contract with C. E. Wilson Construction Co.

● **R. H. Fulton & Co., Box, 1526, Lubbock, Texas.**

Natural Gas Pipeline Co. of America —188 miles of 24-in. from Weatherford, Oklahoma, to Ashland, Kansas.

Michigan-Wisconsin Pipe Line Co. — 250-mile, 24-in. in Kansas, Missouri, Iowa. Also 24 miles of 6-in. near Sun Prairie, Wisconsin.

● **Hall Construction Co., 1105 N. Carlton, Liberal, Kansas.**

Panhandle Eastern Pipe Line Co.—a 330-mile, 4 through 12-in. gathering system in western Kansas. Supervising are Mike Bell and M. E. Banning.

● **Harford Bros. Co., Box 191, Emporium, Pennsylvania.**

The Manufacturers Light and Heat Co. — 22 miles of 6-in. between Farmington and Connellsville, Pennsylvania.

New York State Natural Gas Co.—a 13-mile welding job on 20-in. pipe with 1-in. wall thickness, near Tamarac, Pennsylvania, where field office is located. Whitey Martin is superintendent, and Monrowe Stevens welding superintendent. An undetermined amount of storage field pipe near Duboise, Pennsylvania, under the supervision of Elmer Landis.

● **Houston Contracting Co., 2807 Buffalo Speedway, Houston 6, Texas.**

Michigan-Wisconsin Pipe Line Co.—92 miles of 24-in. natural gas pipeline from Appleton to Marshfield, Wisconsin, with R. L. Silar as superintendent, R. R. Lytle as assistant superintendent, D. L. Marley as field office manager, and present headquarters at Stevens Point.

Sibon Pipe Line Co.—Mississippi River crossing consisting of three 6-in. products pipelines near White Castle, Louisiana. R. E. Thornton is superintendent and Harry K. Mayes is field office manager.

Texas Gas Transmission Corp. — four 30-in. loops consisting of approximately 25 miles in Quachita, Caldwell, La Salle, Grant, Rapides, and Evangeline parishes, Louisiana. Headquarters: Monroe. Superintendent: L. A. Young.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

● **Majestic Contractors Ltd., 49 Jackes Ave., Toronto 7, Ontario, Canada.**

Federated Pipe Lines Ltd.—14 miles of 6-in. and 19 miles of 6 through 8-in. crude oil pipeline in the Swan Hills area, Alberta, under the supervision of K. B. Killingsworth and Jeff Minter. Also, 41 miles of 16-in. from Oliver to Highbridge, Alberta, under the supervision of Jeff Minter at Morinville. Also, approximately 37 miles on 16-in. loops northwest of Edmonton.

Michigan-Wisconsin Pipe Line Co.—60 miles of 30-in. near Joliet, Illinois, where R. L. Leonard is supervising.

● **Mannix Co. Ltd., 737 Eighth Ave., S.W., Calgary, Alberta, Canada.**

Pembina Pipe Line Ltd.—70 miles of 3 through 10-in. in the Pembina oil fields of Alberta, part of a continuing contract of which over 500 miles have been constructed to date. Headquarters: Drayton Valley. Superintendent: S. Steffen.

Northern Ontario Pipe Line Crown Corp.—compressor station with building extensions at Port Arthur, Ontario—part of the Trans-Canada Pipe Line system. J. Hobbs is superintendent and M. Zambory office manager at Kenora.

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Fort Madison, Iowa

● **H. A. McGinnis Construction Co., N. Dumas Ave., Dumas, Texas.**

Shamrock Oil & Gas Corp.—taking up 25 miles of 6-in. from Clawson pump station to Spearman, Texas, where field office is located, and laying same amount of 8-in. Superintendent: J. F. Crawford. Foreman: C. D. McGinnis.

● **McVean and Barlow, Inc., Box 151, Odessa, Texas.**

Mid-America Pipeline Co.—231 miles of 4, 6, and 8-in. LPG pipeline from Artesia, New Mexico, to Midkiff, Texas, under a sub-contract from Williams Bros. Co.

● **Missouri Valley Dredging Co., Box 1592, Burlington Station, Omaha 8, Nebraska.**

Mid-America Pipe Line Co.—Kansas and Missouri river installations.

● **Montin-Harbert Pipe Line Construction Co., Inc. 2808 First National Bldg., Oklahoma City, Oklahoma.**

Mustang Fuel Corp.—an 8 and 12-in. natural gas pipeline system in central Oklahoma. This is a joint contract with Sadler Bros. Pipeline Construction Co.

● **Panama, Inc., 1801 Tennessee Bldg., Houston 2, Texas.**

Continental Oil Co.—8 miles of 24-in. and 65 miles of 16-in. beginning in Lake Charles, Louisiana, and extending to the Maurice-Milton areas in Vermilion Parish. Headquarters: Iowa, Louisiana. Superintendents: T. O. May and C. J. Hendrickson.

● **Panama-Williams Corp., 1418 Melrose Bldg., Houston, Texas.**

Northern Natural Gas Co.—150 miles of 30-in. loops in Iowa, Minnesota, Nebraska, Kansas, and Oklahoma, under the supervision of M. E. Sutton at Clarion, Iowa.

Peoples Gulf Coast Natural Gas Pipeline Co.—60 miles of 30-in. pipeline from Nacogdoches, where field office is located under the supervision of W. H. Shiflett, to Leggett, Texas.

● **Parkhill Truck Co., Box 3807, Tulsa, Oklahoma.**

Natural Gas Pipeline Co. of America—pipe stringing under a sub-contract from River Construction Co. for loops in Iowa. Superintendent: Leon Weston.

Northern Natural Gas Co.—pipe stringing under a sub-contract from Panama-Williams Corp. for various loops in Iowa, Minnesota, Nebraska, Kansas, and Oklahoma. Field office: Ogden, Iowa.

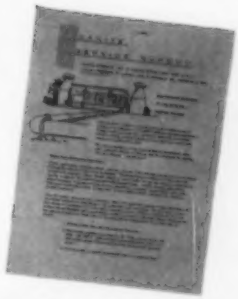
● **Pentzien, Inc., 1504 Dodge St., Omaha, Nebraska.**

Texas Gas Transmission Corp.—installation of a single 30-in. crossing of the Red River near Alexandria, Louisiana, where field office is located. Superintendents: C. E. Zarn and James Bouyear.

Texas Eastern Transmission Corp.—dual 24-in. pipeline crossings of the Juniata River and west branch of the Susquehanna near Lewistown and Renovo, Pennsylvania, respectively. Superintendent: Forrest H. Andrews.

● **Prairie Construction Co., Box 1526, Lubbock, Texas.**

Northern Natural Gas Co.—114 miles of 2 to 12-in. in Iowa.



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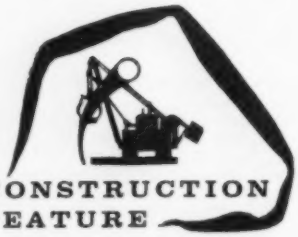

● **Piggott Construction Ltd. (Pipeline Div.), 608 Renfrew, Rideau Towers, Calgary, Alberta, Canada.**

The British American Oil Co. Ltd.—an 8-mile, 8, 10 and 12-in. gas gathering system at Rimbey, Alberta. Bob Telford is superintendent, J. E. Stafford is assistant superintendent, and C. L. LeBlanc is office manager.

● **Pipe Line Technologists, Inc., 3431 Alabama, Houston, Texas.**

Seadrift Pipeline Corp.—a 108-mile products pipeline from Union Carbide Corp.'s Seadrift, Texas, plant to Humble Oil & Refining Co.'s King Ranch plant at Ella, Texas.

● **Pipeline Welding Co., 5100 E. 17th St., Tulsa, Oklahoma.**

Northern Natural Gas Co.—163 miles of 3 to 24-in. in Minnesota.

● **H. C. Price Co., Price Tower, Bartlesville, Oklahoma.**

Midwestern Gas Transmission Co.—55 miles of 24-in natural gas pipeline in Minnesota from a point near Belle Prairie in Morrison County to a point near Bluffton in Ottertail County. This spread, headquartered at Staples, is under the supervision of G. A. "Abe" Reutzel.

Rocky Mountain Natural Gas Co., Inc.—a 172-mile transmission line from Colbran, Colorado, south to Montrose, Colorado. Bill Millburn is office manager, and K. N. "Spike" Adkins is in charge of construction of the cross-country line.

Peoples Gulf Coast Natural Gas Pipeline Co.—83 miles of 30-in. from Stoddard County, Missouri, to Jackson County, Illinois.

● **R. E. Reutzel Co., Box 15, Fremont, Nebraska.**

Northern Natural Gas Co.—89 miles of 2 to 6-in. in Iowa.

● **River Construction Corp., Box 9127, Fort Worth 7, Texas.**

Natural Gas Pipeline Co. of America—95 miles of 36-in. in Iowa, from Haskins to Rose Hill and from Stennett to Pacific Junction. Field office: Washington, Iowa.

Peoples Gulf Coast Natural Gas Pipe-Line Co.—75 miles of 30-in. in Arkansas between Pulaski and Jackson counties.

● **Robb Construction Co., Ltd., 1237 Albert St., Regina, Saskatchewan, Canada.**

Saskatchewan Power Corp.—the Assiniboia and Ormiston-Claybank transmission lines, consisting of approximately 104 miles of 6 and 4-in. L. Brassard is superintendent.

● **Rosson-Richards Companies, Box 35037, Houston 35, Texas.**

Natural Gas Pipeline Co. of America—24, 30, and 36-in. river weights between Clinton, Oklahoma, and Chicago, Illinois. Superintendent: J. Alexander.

Peoples Gulf Coast Natural Gas Pipeline Co.—24, 30, and 36-in. river weights between Katy, Texas, and Chicago, Illinois.

● **Sadler Bros. Pipeline Construction Co., 617 Cravens Bldg., Oklahoma City, Oklahoma.**

Mustang Fuel Corp.—an 8 and 12-in. natural gas pipeline system in central Oklahoma. This is a joint contract with Montin-Harbert Pipe Line Construction Co., Inc.

● **Sharman, Allen, Gay & Taylor, Inc., Box 13152, Houston, Texas.**

Peoples Gulf Coast Natural Gas Pipeline Co.—60 miles of 30-in. from Hope, Arkansas, to Bloomburg, Texas. Field office: Hope. Superintendent: E. D. Singleton.

● **Somerville Construction Co., 6648 Fulton Rd., Ada, Michigan.**

Michigan-Wisconsin Pipe Line Co.—70 miles of 30-in. pipeline loops in Michigan: from Howard City to Jenison and from Pullman to Niles. Field office: Rockford. Superintendent: Harold Cook.

● **Stanley-Bledsoe Corp., 612 Daniel Bldg., Tulsa 3, Oklahoma.**

Peoples Gulf Coast Natural Gas Pipeline Co.—57 miles of 30-in. from Shelby County, Illinois, northerly through Moultrie County to a point of tie-in to the main line, Piatt County. Headquarters: Sullivan. Superintendent: Denver L. Franklin.

● **Turriff-Burden, Ltd., Box 5216, Tulsa, Oklahoma.**

Iraq Petroleum Co. Ltd.—315 miles of 30 and 32-in. pipeline from Kirkuk to the Syrian border, connecting Rumaila and Fao. W. T. Barker manages the project office in London, England. Field construction superintendent is John H. Miller; assistant superintendent is Arnold Smith; and manager of the field office in Baiji, Iraq, is G. E. Suagee.

● **Western Pipe Line, Inc., Box 1076, Austin 66, Texas.**

Texas Eastern Transmission Corp.—35 miles of 30-in. in Pennsylvania, with field office at Lebanon; and 45 miles of 30-in. in West Virginia and Pennsylvania, with field office at Moundsville, West Virginia. W. E. Wells is superintendent of the former, J. R. Wells is superintendent of the latter, and R. L. McMillon is general superintendent for both.

● **J. O. (Red) Willett Pipe Line Stringing Corp., Box 2836, Monroe, Louisiana.**

Peoples Gulf Coast Natural Gas Pipeline Co.—to unload and rack, haul and string approximately 60 miles of 30-in. Headquarters: Hope, Arkansas. Superintendent: J. W. Cathey.

● **Williams Bros. Co., National Bank of Tulsa Bldg., Tulsa, Oklahoma.**

National Iranian Oil Co.—a 240-mile, 8-in. petroleum products line in Iran from Rey, near Tehran, northeast to Sharud.

Alaska Pipeline Co.—74 land miles of 12-in. pipeline from the Kenai Unit gas field to Anchorage, Alaska.

Mid-America Pipe Line Co.—four construction spreads have now completed 541 miles of this 1800-mile LPG pipeline.

● **C. E. Wilson Construction Co., 3718 W. 95th St., Kansas City 15, Missouri.**

Cenex Pipeline Co.—a 190-mile, 8-in. products system in Montana and North Dakota. This is a joint contract with D. Michael Curran & Co.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

PIPELINE PARADE

. . . in equipment, services, sales

T. P. Walker

Tom P. Walker, former board chairman and president of Transcontinental Gas Pipe Line Corporation and still a member of the Transco board, has been elected to the board of **Burgess-Manning Company.**

Formation of a new lubricated plug valve division, with sales and service headquarters in Houston, Texas, is announced by the **Walworth Company.** It is headed by Walworth's new vice president in charge of lubricated plug valve operations, Clyde W. Cook. R. Fred Klein is assistant vice president of the operation.

The Cooper-Bessemer Corporation announces the retirement of Stanley E. Johnson as vice president and director of sales and the appointment of Grant C. Woodard, formerly general sales manager, as vice president of marketing. The company also announces plans to construct a new building to house its recently-formed En-Tronic Controls division.

Victaulic Company of America has appointed Albert C. Moeser, formerly vice president of the W. E. Duncan Company, as sales representative in the Southeastern area.

Terry W. Russell, a 20-year veteran of pipeline and producing phases of the petroleum industry both domestic and foreign, has joined **International Controls Corporation** as vice president of sales and a member of the board of directors. He was one of the original members of the automation division formed by Dresser Industries.

T. W. Russell

Noble Sherwood, formerly chief engineer of A. O. Smith Corporation's space-ordnance division, has been appointed technical director of the reinforced plastics division — replacing Archie Anderson who has returned to the company's research and development division.

Joseph A. Heineman, Jr., a salesman in Jones & Laughlin Steel Corporation's Tulsa office, has been promoted to resident manager of sales there. He joined J&L in 1948 as a sales correspondent at the Cleveland sales office and was assigned to Tulsa in 1951.

A new manager of pipe and tube sales for Bethlehem Steel Company has been appointed. He is Charles W. Ganzel, former manager of sales for the company's Cleveland district. He succeeds Edwin A. Buxton, who is retiring after more than 43 years with the company. Frederic W. West, Jr., assistant manager, plate sales division, succeeds Ganzel at Cleveland; and William E. Hotaling of the company's New Haven, Connecticut, sub-office succeeds West.

SOMASTIC®

Low-Cost Permanent Pipeline Protection

This is Somastic. It has high dielectric resistance and is moisture proof. It has tensile strength to meet severe soil stresses and depression forces. It has outstanding resistance to corrosive soils. Somastic is without question the finest pipeline protection available today.

Somastic provides lowest cost protection in both difficult and normal exposures because it gives virtually permanent protection.

Write for data giving complete facts on the advantages of Somastic.

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A subsidiary of American Pipe and Construction Co.

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Wilmington, California • P.O. Box 457
Phones: SPruce 5-3273 — TErminal 5-8201

Rail Address, Pacific Electric,
Watson, California

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OVER
98%
OF
NATURAL
GAS
PIPE LINES
IN THE U.S.A.

Use
McCORD
LUBRICATORS

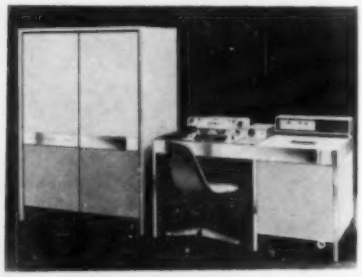
TRULY THE
STANDARD
OF THE
INDUSTRY

Lubricator
Division
McCORD
CORPORATION
Detroit 11, Michigan

It's New | Pipeline Equipment

8000-Word Memory: Expanded Data-Handling

An advanced process control digital computer system capable of accepting data directly from analog instrumentation and providing for closed-loop operation is the "Libratrol-1000" — which includes an advanced memory unit, new developments in read and write head design, and a built-in voltage-to-digital converter. It



is a completely transistorized, two-address, electronic, digital computer system designed especially for new, advanced areas of process control, the manufacturer explains. It operates in the serial, binary mode and offers expanded data-handling capabilities because of the 8000-word memory and a new concept in data placement and recovery. All computing elements, except the input-output devices, are sealed within an air-tight enclosure. A self-contained refrigeration system within the main cabinet maintains the temperature and atmosphere of the electronic computing equipment at levels conducive to maximum reliability and long life. *Librascope Div., General Precision Inc.*

Circle number (81) on reply card.

Algebraic Compiler, Self-Teaching Manual

To bring computers directly within reach of every engineer, Bendix has developed the ALGO algebraic compiler. ALGO, a universal language programming system, is said to allow anyone with a knowledge of high school algebra to program engineering problems as they are being analyzed. Its close parallel to algebra is said to allow inexperienced programmers to solve problems on the computer with the aid of a self-teaching manual that makes previous knowledge of computers and programming technique unnecessary. Completely self-contained, ALGO has facilities for computer control, input and output, program preparation, operation, and check-out. With insertion of the routine into the computer, all instructions and data are handled automatically. The compiler is available at this time to Bendix G-15 users; the self-teaching manual to both users and non-users. *The Bendix Corp., Computer Div.*

Circle number (82) on reply card.

Coating By Spray

Now a user, right in his shop, can spray apply "Scotchkote" No. 101, a one-part powdered 100% epoxy resin, for corrosion protection of complex fittings such as leak clamps and couplings. Sprayed on heated parts with a flocking gun, the resin cures in less than 60 sec, is completely thermoset, will not flow under pressure nor upon heating, has an adhesion strength of more than 3000 psi, and resists attack by most chemicals, including hydrocarbons. Other equipment needed for its application includes: heating equipment (any oven or other heat source that will heat to 425-450 F); a means of cleaning the parts to be coated (sand, shot blasting, solvents, or pickling); an air source (a minimum of 40 psi air pressure, from a compressor or other source, is suggested); a spray booth; and preferably a dust collector. A commercial grade flocking gun with adjustable air and orifice controls should be used for best results. *Minnesota Mining and Manufacturing Co.*

Circle number (83) on reply card.

The MINIATURIZED-PRECISION
WILKINSON Line Locator Model W-3

This radically new, super-powered, transistorized instrument weighs only four pounds and is one-fourth the size of conventional pipe locators.

It is as handy as a flashlight;
the maintenance is trivial;
the non-leak miniature batteries last ten times longer. Long-life transistors eliminate replacement. Molded glass fibre cases. Transistor ear set. Telescopic handle Etches circuitry. Contained in carrying case.

WILKINSON PRODUCTS COMPANY
"SINCE 1940"
3987 Chevy Chase Drive • Pasadena 3, California • SYlvan 0-4314

NO PLACE FOR SISSIES

MOTOROLA 2-WAY RADIO TAKES A BEATING...
because it's built to take it!

A 2-way radio is a precise, complex electronic instrument. But unless it is *rugged* too—unless it can shrug off jolts and vibration and come back for more—it just can't go to work in the oil fields.

Motorola engineers *design* a radio to take it. Extensive field tests *make sure* it's no sissy—Motorola literally beats the "bugs" out. Then a tough, rigid quality control setup *keeps* them out.

This kind of consistent leadership in research, development and engineering has led to a radio that will stand up to rough treatment and still deliver dependable service—day after day. You'll see *why* when you check with your local Motorola representative—he'll give you all the facts. Write:

MOTOROLA 2-WAY RADIO

Motorola Communications & Electronics, Inc., 4501 Augusta Blvd., Chicago 51, Illinois • A Subsidiary of Motorola Inc.

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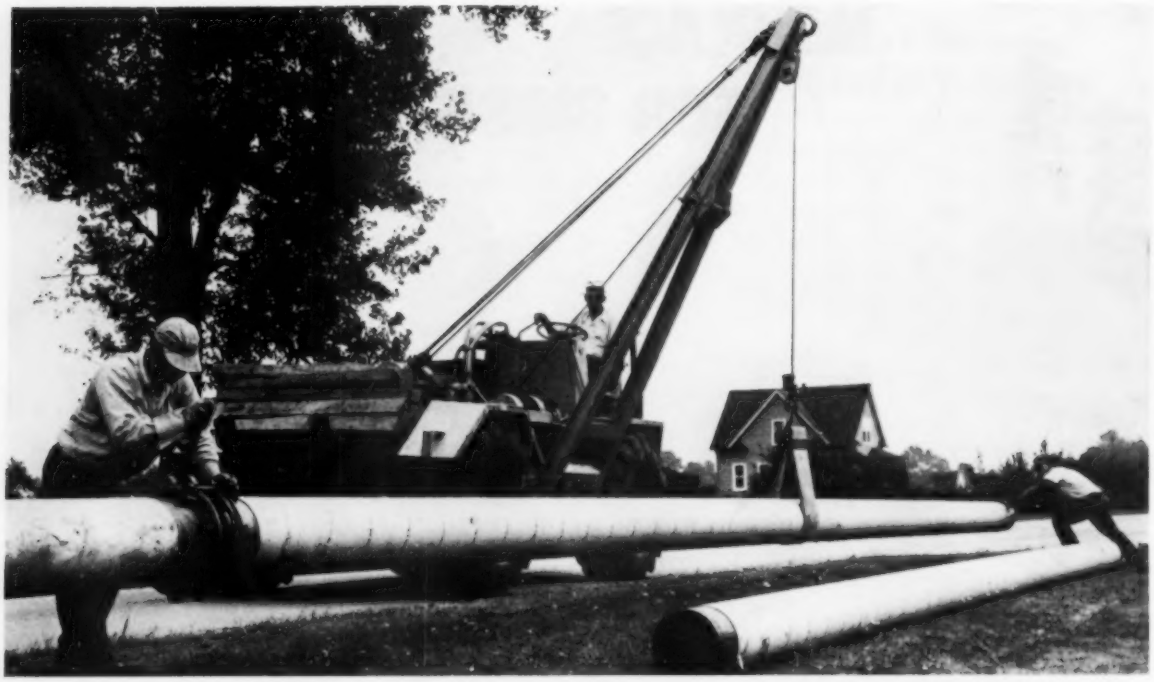


A leading Midwest Contractor reports on the New FWD Blue Ox Side Boom . . .

". . . now, instead of picking up just one 45 ft. length of pipe, we can pick up three at a time with the FWD Side Boom"

Contracting and Material Co., Evanston, Ill., general contractor, like most present-day contractors, tries out equipment before buying. This firm tried several rubber-tired pipe-laying rigs before selecting and buying the new FWD Side Boom.

Ed Van Cleave, superintendent of the firm, sums up the performance of the FWD Side Boom on a current pipe-laying job in South Chicago:

"It's an outstanding day-in and day-out performer. There's no question that the FWD Side Boom we own and operate is doing a good job for us on this pressure improvement gas line project. We're laying four and one-half miles of eight and 12 in. pipe. This pipe weighs 25 lbs. to the foot. We can pick up three 45 ft. lengths and move them into tacking position for the welder without any trouble. Working adjacent to black-top roads makes it essential to operate a rubber-tired rig. It's ideally suited for this type of work."

Blue Ox

*Blue Ox is an FWD TRADEMARK

THE FWD SIDE BOOM HAS • SPEED • POWER • VERSATILITY • RELIABILITY • MOBILITY . . . for pipe line construction, sewer, material handling, erection work, valve setting, general construction and public utility work. If you're considering the addition of a rubber-tired pipe-laying unit for your spread, check . . . feature by feature . . . the FWD BLUE OX SIDE BOOM with any similar rubber-tired pipe-layer.

NEW CUSTOM ENGINEERED RUBBER-TIRED PIPE-LAYING RIG FOR GAS DISTRIBUTION WORK! Pound for pound . . . dollar for dollar . . . you'll get MORE profitable production with the FWD BLUE OX SIDE BOOM.

See for yourself—on your job—how the NEW FWD SIDE BOOM can speed up your pipe-laying operation.

Your FWD Dealer will demonstrate.

FWD CORPORATION

CLINTONVILLE, WISCONSIN
CANADIAN FACTORY • KITCHENER, ONTARIO

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

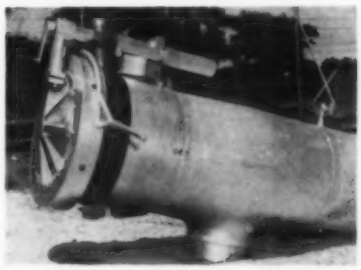
New Clamp Facilitates Connecting To Pipeline

Consisting of a high conductivity bronze body equipped with a chain and speed-screw for attaching to all pipe sizes from 2-in. up, a new "Quick-Bond" clamp can be applied in less than 15 sec to give a positive, low resistance contact. It provides a quick way of connecting any cable to pipe for: arc welding; cathodic-protection pipe measurements; jumpering or any

other temporary electrical connection to pipelines. The clamp has no loose parts, may be attached permanently to the cable for ready use, and is said to handle 300 amp easily. *Pipetron Co.*

Circle number (84) on reply card.

Closure With Head That Swings 90° From Body



For scraper traps, gas scrubbers, pipeline strainers, and pressure vessels is a new quick-opening closure, the head of which can be swung 90 deg from body to permit complete access without interference from other parts of the closure. The closure head, having a beveled seat and "O" ring gasket, is axially movable on an overhead arm which swings laterally about a pedestal to expose the full open end of the body. The closure head assembly is moved by a hand crank attached to a threaded shaft in the overhead arm. To close, the head is swung back into position and the hand crank operated to move the head with the threaded nut into position for engagement with the threads on the body. During opening or closing, the "O" ring does not rub against any part of the head or body, the manufacturer states. *Moorlane Co.*

Circle number (85) on reply card.

Spy Detector

QUALITY SERVICE

is there . . . when you need it!

. . . our SPY HOLIDAY DETECTORS are as near as your telephone—in fact, in emergencies our own plane assures immediate service.

Rugged equipment for dependable holiday detection on ¾" to 36" pipe . . . signal—bell, light and spark . . . unaffected by dew or frost.

Call, wire or write.

Pipeline Inspection Co., Inc.

2104 WYANDOTTE STREET • KANSAS CITY, MISSOURI

Day Phone: BAltimore 1-6036

Night Phone: HI 4-6745, EM 1-3824

FLEET-LINE

WELDING FITTINGS

•

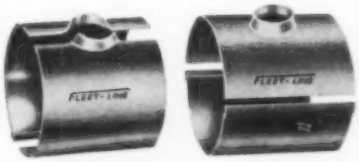
LITERATURE BY AIR MAIL . . .

. . . ask for it now.

REDUCERS: Concentric and eccentric. Nominal pipe sizes 1" to 30", ASA B16.9, ASTM A234. Schedules 10 to 160, stainless steel, and other alloys. Special lengths and sizes.

SADDLES: Conventional, and for pressure vessel heads. Nozzle sizes from ¼" to 24". Fleet-Line saddles weld neatly into place in much less time, and with much less welding rod.

Full encirclement saddles.



REDUCING TEES, Forged Steel Manifold Type.

Dealers and Stocking Distributors throughout the United States and Canada.

All orders acknowledged by air mail or long distance telephone and filled at once.

STEEL FORGINGS, Inc.

P. O. Box 276A • Shreveport, La.

Tunnel Diode Adapted For Microwave Signals

One of the newest devices in the electronics field—the solid-state tunnel diode, a semiconductor device no larger than a small pill — has been adapted for producing microwave signals in a new, tunable tunnel-diode oscillator. The new device, now available on a sampling basis, is a package approximately 6 in. by 3 in. by 5/8 in. in size, exclusive of tuning dial and connectors, and less than 1 lb in weight. Application of only 0.2 v to the oscillator unit produces a power output of several tenths of a mw, tunable over the 100-1400 mc band. Elimination of filaments, operation at very low voltages, and adaptability of the small tunnel diode to very small microwave circuits make possible the generation of low-power microwave signals in small units having long life and reliability, the manufacturer states. *Radio Corp. of America*

Circle number (86) on reply card.

Car Cigarette Lighter Recharges 2-Way Radio

Announced is a new portable two-way radio which can be used for two days without any battery charging at all and then can be recharged by using a car's cigarette lighter or an electrical outlet. For applications where no outlet is available, the new unit may be obtained with a seven-day dry pack. Key to the re-charging is a built-in battery charger used with a 12-v dc vehicular system or 117-v ac. A rechargeable nickel cadmium power supply saves battery replacement costs and enables the portable to be placed on constant charge on a shelf while awaiting use. The new unit contains an all-transistorized receiver. It can be operated in the 25-54 mc and 144-174 mc frequencies, which means it may be used to transmit to existing vehicular two-way radios, pocket units, or portable-to-portable. *General Electric Communication Products Dept.*

Circle number (87) on reply card.

Finds Underground Shorts On Coated Line

A new technique of pinpointing on a coated pipeline underground electrical shorts within inches, using Pearson-type equipment, employs a 5 to 10-w current of audio frequency applied directly to the pipeline. The resulting electrical field can then be intercepted and measured with an inductance coil and easily followed to the point of a foreign electrical contact. The model PD detector assembly for this application includes: a transistorized oscillator, operating on a 12-v automobile battery, which generates a 15-v, 750-cycle, stable a-c audio frequency signal on a pipeline at a conversion efficiency of better than 70 percent; a 14-oz belt-worn receiver, operating on a 1000-hr-life mercury battery, with two 750-cycle resonate filters to reject unwanted signal; and one set of head phones and compartmentized carrying case. *Tinker and Rasor*

Circle number (88) on reply card.

It's New | Pipeline Literature

Maintenance Painting Guide . . . a 24-pager with sample colors . . . discussing various types of primers and finish coats for maintenance painting of plants, machinery, and equipment and detailing the properties and recommended application methods of a number of special-purpose paints. One section of the guide details the steps necessary for proper surface preparation, and a 2-page chart pinpoints recommended finishes for different types of surfaces and indicates resistance of each finish to chemicals and other destructive agents. *Industrial Maintenance Div., The Sherwin-Williams Co.*

Circle number (89) on reply card.

Gravitometer Manual . . . on the new Sinclair-Cenco 35090, which makes continuous "on-line" measurements of specific gravity of flowing liquids from within a 40 deg API range for use in controlling continuous blending of liquids, routing pipeline runs to remote bulk storage, or almost any situation where handling of bulk fluids may be automated. The 19-pager . . . detailing applications, installation, operation, and maintenance . . . is illustrated with photos, graphs, charts, and diagrams — one showing exactly how the measuring instrument functions and what the electrical set-up is for the transducer, power supply, and gage adjustment. There is also a 2-page table for converting degrees of API into percent of span in the gravity range of 30 deg API to 70 deg API. *Central Scientific Co.*

Circle number (90) on reply card.

Glove Guide . . . a new selector manual covering basic types and styles of work gloves. Buyers, safety engineers, and purchasing agents will find: tips on grades of leather, chemical resistance and physical properties of various plastic coatings; basic features of canton flannel, jersey, leather, terry cloth, neoprene, plastic and rubber coated, hot mill and welders; and on-the-job case histories. *Riegel Textile Corp.*

Circle number (91) on reply card.

Detection of Pre-Explosive Accumulations of Gases is the function of Detectogas Air Density Monitor . . . described in a new bulletin as continuously and automatically sensing changes in air density due to gas infiltration and triggering any types of alarm system. The unit automatically compensates for changes in temperature, humidity, and atmospheric pressure. *Detectogas Instruments, Inc.*

Circle number (92) on reply card.

Gas Regulators, Portable Manifolds . . . comprehensively described and illustrated in 16 pages that include complete specifications, uses, and installations for regulators for use with all industrial gases and portable manifolds for use with oxygen and acetylene. Inlet and outlet connections are listed according to American Standards of the Compressed Gas Association. In addition to covering single and two-stage regulators for station and manifold service, the catalog also describes a new line of single-stage regulators *without gages* for field service where cylinder regulators are changed often. *Linde Co., Div. of Union Carbide Corp.*

Circle number (93) on reply card.

Utilizing Gas Pressure from the pipeline and easily mounted in any position is a new valve operator for application on rotary plug valves of any size. An 8-page bulletin describes the construction and mechanical features of the "G" series gas operator by Limitorque and installation and manual operation. Various schematic control diagrams are clearly illustrated. *Philadelphia Gear Corp.*

Circle number (94) on reply card.

NEW Casing Seal!
WmSON "U" SEAL

MAINTAINS TIGHT SEAL
EVEN WHEN DRAG SECTION
CHANGES POSITION IN CASING

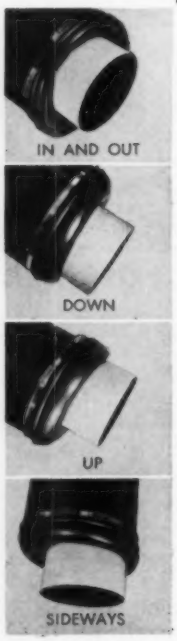
This versatile and flexible "U"-Seal offers NEW ECONOMY in casing seals.

The special demonstrator pictured shows the flexibility of the "U"-Seal. The pipe position changes, but the seal remains tight. A special fungus and bacteria retardent is added to the compound for extra protection. Seals available in sizes 2" and larger.

VERSATILITY OF INSTALLATION

The fully reversible "U"-Seal is easy to install in the new "U" shape or in WmSon's familiar "Z" shape. A screwdriver is the only tool needed to tighten the two stainless steel bands. Send for technical bulletin.

YOU CAN SEAL WITH A "U"-SEAL



Write Dept. B2
for Bulletin A-281

T.D. Williamson, Inc.
P. O. BOX 40 TULSA 2, OKLAHOMA

REPRESENTATIVES AROUND THE WORLD

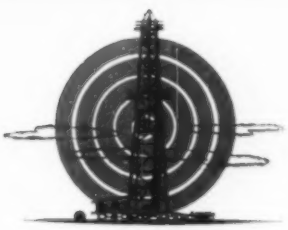
11

SUP

Rig Locator

supplement to

THE PETROLEUM
Engineer



FALL 1960

This exclusive summary of rigs available for contract work includes: rig location, type of equipment, rig specifications, contractor's address. Major divisions: Rotary, Cable Tool and Well Servicing . . . plus, offshore drilling units and some rigs in foreign service.

Drill Collars

Perfection in every detail–

- *thread form*
- *trepanned bore*
- *wall thickness*
- *balance*
- *metallurgy*

THREE CONE BITS

Chicago Pneumatic
FORT WORTH, TEXAS

DRILL COLLARS

REAMING BITS

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SIXTEENTH EDITION FALL 1960

RIG LOCATOR

Including U. S. and Canadian Well Servicing Units

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United States and Canadian

RIG LOCATOR

Five Continuous Years

With the printing of the 1960 Fall Edition of *The Petroleum Engineer's* exclusive **Rig Locator,** we celebrate five consecutive years of this unique rig directory service for the drilling and well servicing industry. The first edition, published in October 1955, gave birth to an idea that has at times been difficult to execute. That first edition listed a little over 1600 rigs. The Fifth Anniversary edition carries listings for over 2800 rigs! (The International Oil Scouts Association and AAODC Rig Report for August 19, 1960, reports a total of 2734 rigs actively engaged . . . i.e., rigging up, tearing down, drilling, logging, cementing, etc.)

Your **Rig Locator** has witnessed good times for the drilling industry . . . especially in 1955 and 1956. It has also watched the difficult days of 1959 and, especially, those of 1960. It has seen the total active rotary rig count go over the 3000 mark and it has observed with serious concern this number dwindle to less than 1700 in recent weekly tabulations. It is reassuring indeed, therefore, to the publishers and editors of the **Rig Locator** to see the number of rigs listed in and the contractors utilizing this free directory service in good times as well as in this current rough period. To us it represents a continued expression of confidence in the purpose of the **Rig Locator:** to provide a means of helping idle rigs be put back to work.

We know from letters received from both contractors and operators alike that the **Rig Locator** has been of concrete aid. It has enabled operators to locate a rig and its owner-operator to drill a well in a specific location; it has enabled a contractor to examine his potential competition when contemplating a rig move into an unfamiliar area; and the rig data published in every edition has provided the basic material for innumerable surveys of many different kinds. One such survey included a study of all rigs available capable of drilling below 20,000 ft. Some 21 rigs were listed at that time. Other surveys are for equipment data and forecasts. In addition to these, **Rig Locator** data is undoubtedly used in surveys and studies of which we are not even aware. You can also determine what percentage of the contractors own what percentage of the rigs. For what it's worth, the present edition shows that the "average" contractor owns and operates 4.27 rigs. This figure is not far from the "average" of five years ago . . . indicating that there are still a large number of small contractors, the number of large contractors not having increased appreciably as one might have expected with the decline of rig activity that we have experienced.

For the past five years, the **Rig Locator** has been published three times a year: March, July and October. This directory service has been, and will continue to be, published at no cost whatsoever to the contractor. This service is made possible only through your continued acceptance and participation. We sincerely thank all those contractors who have, year in and year out, cooperated with us. We always welcome new listings *and* we also welcome your comments and suggestions.

Use of Abbreviations

In a directory of this type where certain specifications are included, it was necessary in the conservation of space to make some abbreviations. The asterisk (*) before the "rig number" indicates the rig is also available for workover. Under the column of "type power," the following abbreviations apply: Dsl for diesel; gaso for gasoline, stm for steam; btne for butane; and dsl elec for diesel electric. In listing drawworks make and model number, it was necessary to abbreviate the manufacturer's name. Some of these abbreviations are well-known; others had to be made to fit the available space. Here's the code we used:

Manufacturer's Company Name	Abbreviation
ALCO Products, Inc. (formerly Beaumont Iron Works Div. of American Locomotive Co.)	ALCO-BIW
Allis-Chalmers Manufacturing Co.	Allis Chmrs
American Iron & Machine Works	Amer
Ansaldo	Ansaldo
Bethlehem Supply Co.	Beth
Big Four Machine & Supply Co.	Big Four
Border Foundry & Machine	Border
The Brewster Co., Inc.	Brwstr
Bucyrus-Erie Co.	B. Erie
Cardwell Manufacturing Co., Inc.	Crdwll
Clark Bros. Co., Inc.	Clark
Continental-Emsco Co.	Emsco
Fred E. Cooper, Inc.	Cooper
Cummins Engine Co., Inc.	Cummins
George E. Failing Co.	Failing
Franks Division of Cabot Shops, Inc.	Frnks
General Machine Co.	Gen Mach
Hacker Machine & Supply Co.	Hacker
Hopper Machine Works, Inc.	Hopper
Houston Tool Co.	Hou
Howard-Turner Machine Works	Howard-Turner
Ideco, Inc.	Ideco
Ingersoll-Rand Co.	Ingersoll
Jones, Shelburne & Guffey Co.	JS&G
Joy Manufacturing Co.	Joy
Lucey Export Corp.	Lucey
Mayhew Supply Co., Inc.	Mayhew
Mid-Continent Supply Co.	M-CSCO
Lee C. Moore Corp.	L. C. Moore
Muskogee Iron Works	MIW
The National Supply Co.	Natl
Oil Well Supply Division (U. S. Steel Corp.)	"Oilwell"
Reich Bros.	Reich
Spencer-Harris Machine & Tool Co.	Spencer
Stardrill-Keystone Co.	Star
Texas Iron Works, Inc.	TIW
Vickers, Inc.	Vickers
Victoria Machine Works	Vic
Wagner-Morehouse, Inc.	Wgnr-Mrhse
Waldrip Engineering Co.	Wldrp
Walker-Neer Manufacturing Co., Inc.	Wlkr-Nr
Well Machinery & Supply Co., Inc.	Ft Wrth
Wheeling Machine Products Co.	Wheeling
The Wheland Co.	Whlnd
Wichita Tool Supply Co.	Wich
Wichtex Machinery Co., Inc.	Wichtex
Wilson Manufacturing Co., Inc.	Wlsn

U. S. Rotary Drilling Contractors

A

A & P Drilling Co Inc Box 568 Duncan Okla
Abb Drlg Co 900 Oil & Gas Bldg Wichita Falls Tex
Ace Drlg Co 1313 Republic Natl Bk Bldg Dallas Tex
Alan Drlg Co 807 Oil & Gas Bldg Wichita Falls Tex
Allen & Morris Drlg Co 820 Alamo Natl Bldg San Antonio Tex
Allen & Shumate Inc P O Box 98 Alice Tex
Allison Drlg Co 626 Patterson Bldg Denver Colo
Aloha Oil Co P O Box 407 Riverdale Calif
An-Son Drlg Co 3814 N Santa Fe Oklahoma City 18 Okla
Appell Petroleum Corp Drawer 330 Alice Tex
Armstrong & Horn Drlg Co 640 Milam Bldg San Antonio 5 Tex
Arrow Drlg Co 407 Philtower Bldg Tulsa 3 Okla
Ashby Drlg Co Ltd 738 Meadows Bldg Dallas 6 Tex

B

B-M Drlg Co Inc Box 5218 Bossier City La
Bailey Pernie 2309 Sage Rd Houston 19 Tex
Barnes Core Drlg Co 1350 Roberts Ln Bakersfield Calif
Barry Well Drlg Co West Star Rt Fallon Nev
Bass Drlg Co 905 San Jacinto Bldg Houston 2 Tex
Bass Robert M Drlg Contr Box 471 Kilgore Tex
Bennett & Roberts Drlg Inc Drawer 633 Russell Kans
Bernhardt Drlg Co 2469 Grand River Detroit 1 Mich
Berry Drlg Co Box 67 Saint Jo Tex
Bickerstaff and Tibbets Drlg Co 406 N. Marienfeld Midland Tex
Big Chief Drlg Co Box 8837 Oklahoma City 14 Okla
Big Horn Drlg Co Inc Box 2068 Casper Wyo
Big Seven Drlg Co 311 Wright Bldg Evansville Ind
Big "6" Drlg Co 225 Oil & Gas Bldg Houston Tex
Big West Drlg Co 1505 Oil & Gas Bldg Ft Worth 2 Tex
Big X Drlg Co Inc 2905 First Natl Bldg Oklahoma City Okla
Black Drlg Co 525 Petroleum Bldg Abilene Tex
Black Henry Drlg Co Inc Box 174 Midland Tex
Blackstock Forest Inc V & J Tower Bldg Midland Tex
Bodard Drlg Co 313 Masonic Bldg Shawnee Okla
Bolin Oil Co & D H Bolin 1120 Oil & Gas Bldg Wichita Falls Tex
Boyd & Durst Drlg Contr Box 329 Alice Tex
Brack Drlg Co Inc Box 575 Fort Collins Colo
Brannon & Murray Drlg Co Box 672 Coleman Tex
Brantly Drlg Co Inc Box 4935 Midland Tex
Brehn C E Drawer 618 Mt Vernon Ill
Brewster-Bartle Drlg Co Inc 1919 Bk of Southwest Bldg Houston 2 Tex
Brooks Zach Drlg Co Box 31 El Dorado Ark
Brown Layton Drlg Co Box 185 Woodsboro Tex
Bryant-Hayward Drlg Co Box 4627 Oklahoma City Okla
Buick Drlg Inc 409 Wolcotte Bldg Hutchinson Kans
Burns Drlg Co 1003 S St James Blvd Evansville 14 Ind
Butler-Johnson Inc Box 306 Shreveport La
Buzzini Drlg Co Petroleum Center San Antonio 9 Tex
Byars B G Power Drlg Co 624 Citizens Bk Bldg Tyler Tex

C

Caldrill Inc 3400 Loma Vista Rd Ventura Canada
Camay Drlg Co 4250 Wilshire Blvd Los Angeles 5 Calif
Camay Drlg Co Rocky Mt Div 1535 Denver Club Bldg Denver 2 Colo
Camden Drlg Co Box 1418 Corpus Christi Tex
Canbridge Corp Ltd Calgary Alberta Canada
Capitan Drlg Co Inc Box 671 Odessa Tex
Capitt Drlg Co 814-16 Union Center Wichita 2 Kans
Caraway Frank Drlg Co Box 982 San Angelo Tex
Carter-Jones Drlg Co Box 1597 Kilgore Tex
Chief Drlg Co Inc 4600-10th St Pl Great Bend Kan
Chiles Drlg Co Box 949 Alice Tex
Clark Dan L Drlg Co 819 Wilson Tower Corpus Christi Tex
Circle Drlg Co Inc 620 Pioneer Bldg Lake Charles La
Clark E B Drlg Co 612 City National Bk Bldg Wichita Falls Tex
Clawson Don Townsend Bldg Ada Okla
Claypool Drlg Co Box 98 St Elmo Ill
Clegg & Hunt 715 Houston Club Bldg Houston Tex
Coastal Drlg Co 7300 Downing Ave Bakersfield Calif
Columbia Drlg Co 1207 C & I Life Bldg Houston 2 Tex
Comet Drlg Co Box 1143 OCS Lafayette La
Conrey Drlg Co 328 E Broadway Centralia Ill
Continental Drlg Co 1010 Commerce Bldg New Orleans La
Continental Marine Expl Co Box 3050 Houston Tex
Cook Drlg Co 2305 Continental Life Bldg Ft Worth Tex
Cooper Drlg Co 902 Staley Bldg Wichita Falls Tex
Coroco Drlg Co 2000 Mercantile Bk Bldg Dallas 1 Tex
Crawford Drlg Co Box 622 Shreveport La
Cross Jess P Drlg Contr 1216 Texas St Graham Tex
Crow Milton Inc 420 Commercial Natl Bk Bldg Shreveport La
Crown Drlg Co 612 First Natl Bldg Oklahoma City Okla

D

D & M Drlg Co Inc 809 Union Center Wichita 2 Kans
Danforth Drlg Co 418 Kennedy Bldg Tulsa Okla
Darden R W Drlg Co Box 576 Olney Tex
Davidson Drlg Co Inc 1004 Continental Life Bldg Ft Worth Tex
Davis H & R H Thompson Co Calif
Davon Drlg Co Box 1586 Oklahoma City 9 Okla
Delaney M J Co 910 Dallas Fed Savings Bldg Dallas 1 Tex
Delta Drlg Co Box 2012 Tyler Tex
Delta Marine Drlg Box 2012 Tyler Tex
Dillard-Waltermire Inc 109 Oil & Gas Bldg Houston 2 Tex
Dillier W L Box 205 Casey Ill
Dixie Drlg Co Inc 2715 Mercantile Bk Bldg Dallas Tex
Dixilyn Drlg Corp Box 3427 Odessa Tex
Dixon Drlg Co Box 2320-340 Pet Bldg Abilene Tex
Dual Drlg Co 606 City Natl Bk Bldg Wichita Falls Tex
Dudley & Heath Drlg Co Box 428 Stillwater Okla
Durham Drlg Co Inc Box 204 Midland Tex

E

Eason T T Co Div of Eason Oil Co Box 9755 Oklahoma City 18 Okla
Edman Drlg Co San Jacinto Bldg Houston Tex
Edwards Harry L Drlg Co Box 35066 Houston 35 Tex
Eggleston A W Inc Box 425 Crowley La
Empire Drlg Co 650 Fourth Natl Bk Bldg Wichita 2 Kans
Empire Drlg Co 1403 Texaco Bldg Dallas 1 Tex
Exeter Drlg Co 919 Midland Svgs Bldg Denver Colo
Exploration Drlg Co Box 406 Whittier Calif

F

FWA Drlg Co Inc 300 1st Natl Bk Bldg Wichita Falls Tex
Fairman Drlg Co Hammersley Fork Pa
Falco Drlg Co Inc Box 1255 Alice Tex
Falcon Seaboard Drlg Co Pan American Bldg Tulsa Okla
Farmer John O Inc Russell Kans
Felderhoff Bros Drlg Co Box 87 Muenster Tex
Field Drlg Co 1901 Milam Bldg San Antonio Tex
Fitzpatrick Drlg Co Inc Box 639 Casper Wyo
Flournoy-Haston Drlg Co Inc Dowling Bldg Ardmore Okla
Foree Drlg Co 607 First Natl Bk Bldg Dallas 2 Tex
Fortenbery Drlg Co Inc Box 273 Natchez Miss
Fortune Drlg Corp Petroleum Bldg San Angelo Tex
Foster C J Drlg Co Inc Box 657 Richmond Tex
Fowler Armstrong Inc 929 Oleander Bakersfield Calif
French Lloyd R 506 V & J Tower Midland Tex
Frio Drlg Inc P O Box 576 Corpus Christi Tex
Frizzell Drlg Co 108 NW 2nd St Oklahoma City Okla
Frontier Drlg & Prod Co 216 Petroleum Life Bldg Midland Tex
Fryer & Hanson Drlg Co 2520 Republic Bk Bldg Dallas Tex

G

Garr-Woolley Oil Co 901 Cravens Bldg Oklahoma City Okla
Garvey Drlg Co Route 2 Great Bend Kans
General Well Drlg Inc Box 1315 Alice Tex
Glenn Gillespie & Sons Inc Box 907 Cushing Okla
Gilmour Drlg Co Box 1082 Alice Tex
Gist Expl Co Box 1731 Casper Wyo
Gober F E Drlg Co 3032 Cherry Ave Long Beach 7 Calif
Goff-Leeper Drlg Co Box 1749 Ardmore Okla
Gore Drlg Co Box 515 Albany Tex
Grace H O Drlg Co 632 Wichita Natl Bldg Wichita Falls Tex
Grace Jack Drlg Co 1009 City Natl Bldg Wichita Falls Tex
Grace Luke Drlg Co 1020 Oil & Gas Bldg Wichita Falls Tex
Gracey-Hellums Corp 410 S Coast Bldg Houston 2 Tex
Graham & Klassen Drlg Co Inc 4715 Crenshaw Blvd Los Angeles 43 Calif
Grappe John Drlg Co Box 1186 Levelland Tex
Graytex Drlg Co 406 Robertson Bldg Wichita Falls Tex
Great Northern Drlg Co Inc 3021 Sixth Ave N Billings Mont
Grey-Wolf Drlg Co 1506 Bk of the Southwest Houston 2 Tex
Guadalupe Drlg Co 2505 Princeton Ave Midland Tex
Guffey Roy Drlg Co 5543 Yale Blvd Dallas 6 Tex
Gwaltney Henry Drlg Co Box 289 Washington Ind

H

H & S Drlg Co 407 Tri State Ins Bldg Tulsa Okla
Hack Drlg Co Box 5108 Abilene Tex
Halbert Drlg Co 607 Citizens Bk Bldg Tyler Tex
Hall Clyde Drlg Co Inc Box 4068 Bakersfield Calif
Hall O E Drlg Co 2008 Continental Natl Bk Bldg Ft Worth 2 Tex
Hamman Oil & Ref Co Box 13028 Houston 19 Tex
Haney & Williams Drlg Co 3500 Cherry Ave Long Beach 7 Calif
Hap Drlg Co 2510 First Natl Bldg Oklahoma City Okla
Harkins & Co Box 1490 Alice Tex
Harris Drlg Co Box 699 Grayville Ill
Haseman John Inc 419 Wilson Bldg Corpus Christi Tex
Helmerich & Payne Inc First Natl Bldg Tulsa Okla
Herb The Expl Co 342 Lexington Ave Abilene Tex
Maxwell Herring Drlg Corp 619 Citizens Bank Bldg Tyler Tex
Hester B M Box 2588 Wichita Falls Tex
Hewit-Gulick Drlg Co 2555 1st Natl Bk Bldg Denver 2 Colo
Hilburn Industries Inc Box 1723 Ricou-Brewster Bldg Shreveport La
Hissom Drlg Co 1327 Wilco Bldg Midland Tex
Holliman Drlg Co 712 Fidelity Union Life Bldg Dallas Tex
Holm Drlg Co Box 7246 Tulsa 18 Okla
Holt Brothers Drlg Co Box 236 Pampa Tex
Hose-Austin Drlg Corp Box 1067 Casper Wyo
Houston M L Drlg Co 616-4 1st Wichita Nat Bk Bldg Wichita Falls Tex
Houston Oil Well Serv Co 504 Waugh Dr Houston 19 Tex
H H Howell 604 Milam Bldg San Antonio Tex
Hull Oil Co 203 Panhandle Bldg Wichita Falls Tex
Hunt Drlg Co Inc 633 Wilson Bldg Corpus Christi Tex

I

Indian Drlg Co Box 42 Tulsa Okla
Ingling Donald T 623 First Natl Bk Bldg Wichita 2 Kan
Inland Drlg Co 317 C A Johnson Bldg Denver Colo
Isern Drlg Co Box 486 Ellinwood Kans
Ivy Drlg Co 1705 Burton Way Bakersfield Calif

J

J & C Drlg Co 311 Citizens Standard Bldg Corpus Christi Tex
Jack S W Drlg Co Allegheny Ave Avonmore Pa
Jet Drlg Co Inc 304 California Bldg Denver 2 Colo
Johnson Al Drlg Co Rt 12 Box 440 Oklahoma City 15 Okla
Johnson Fred Drlg Co 2790 Cherry Ave Long Beach 6 Calif
Johnson-Gadbois Drlg Co 200 Petroleum Bldg Abilene Tex
Jones Woody Drlg Co 408 E Main St Olney Ill
Justiss-Mears Oil Co Inc Box 396 Jena La

K

K & E Drlg Inc 719 Union Center Bldg Wichita 2 Kans
Kellogg K L & Sons 3777 Long Beach Blvd Long Beach 7 Calif
Kendall-Davis Drlg Co Inc 201 S E 1st St Evansville Ind
Kendrick Bros Drlg Co 121 E Louisiana St Vivian La
Kent Drlg Co Box 2555 Salt Lake City 10 Utah
Kern Drlg Co Inc Box 699 Magnolia Ark
Kerr-McGee Oil Industries Inc Kerr-McGee Bldg Oklahoma City Okla
Kilroy Drlg Co 2306 Bk of Southwest Bldg Houston 2 Tex
Kimbark Expl Co Box 1557 Denver Colo
King Carl B Drlg Co of Tex Box 270 Midland Tex
King-Phillips Inc 1108 Continental Natl Bk Bldg Ft Worth Tex
Kingery Drlg Co Inc Box 97 Saint Jo Tex
Kirby Oil Ind Inc 5107 Center St Omaha 6 Neb
Kirkpatrick Oil Co 1300 N Broadway Oklahoma City Okla
Knappenberger A F Box 1139 Graham Tex
Knight Drlg Co Box 1332 Bakersfield Calif

L

L & J Drlg Ltd 7 Empire Bldg Calgary Alberta Canada
L & N Drlg Co Box 8057 6709 Canal Blvd Shreveport La
Layton & Newell Drlg Co 1505 Oil & Gas Bldg Ft Worth 2 Tex
Leatherwood Drlg Co Box 925 Jacksboro Tex
Lee Drlg Co 1007 Philtower Bldg Tulsa Okla
Lewis Bros Inc 310 U S Natl Center Bldg Denver 2 Colo
Lewis Will I Drlg Co 207 Continental Oil Bldg Denver Colo
Lincoln Drlg Co 403 Oil & Gas Bldg Oklahoma City 2 Okla
Lindsay Ted Box 190 Mt Vernon Ill
Lin-Mour Drlg Co 1112 Oil & Gas Bldg Wichita Falls Tex
Lloyd Drlg Co Box 355 Taft Calif
Lohmann-Johnson Drlg Co Inc 320 Indiana Bk Bldg Evansville Ind
Louisiana Delta Offshore Corp 201 Carondelet Bldg New Orleans La
Love-Miller Drlg Co Inc 712 Patterson Bldg Denver 2 Colo
Low Drlg Co Box 1112 Cisco Tex
Lowe Drlg Co Box 832 Midland Tex
Lunsford Drlg Co 505 Louisiana Bk Bldg Shreveport La
Lynn Drlg Co 1403 Natl Bk of Tulsa Bldg Tulsa Okla

M

Mac Drlg Co Box 2972 Houston 1 Tex
Macrate Prod Co 3341 Cherry Ave Long Beach 7 Calif
Mallard Drlg Co 1016 Union Natl Bk Bldg Wichita Kans
Man Drilling Co 200 City Natl Bk Bldg Wichita Falls Tex
Manning R L Co 318 Continental Oil Bldg Denver Colo
Maritzky & Bibby Box 509 Homer La
M L (Mike) Marrs Drlg Co Box 985 Drumright Okla
Martin Dee Drlg Co Box 731 Gainesville Tex
Martin Lubie Drlg Co 2052 Harvard Houston Tex
Mast Drlg Inc Box 33 Russell Kans
McCall Gabe Drlg Co Box 2068 Casper Wyo
McCutchin Gene Drlg Co Box 1585 Dallas 21 Tex
Meadows & Walker Drlg Co 500 San Jacinto Bldg Houston 2 Tex
Medford Drlg Co 500 Wichita Natl Bk Bldg Wichita Falls Tex
Melco Drlg Co Box 1360 Seminole Okla
Meredith & Co 1418 Bk of the Southwest Bldg Houston 2 Tex
Meredith Drlg Co 419-420 City Natl Bldg Wichita Falls Tex
Mesker Drlg Co Box 3655 Tulsa Okla
Midwestern Drillers Inc 1206 Mid-Continent Bldg Tulsa 3 Okla
Milam Drlg Co 1814 Alamo Natl Bldg San Antonio Tex
Miller Bros & Bowling Box 611 Alice Tex
Miller Joe A Drlg Contr 2001-12th Street Brownwood Tex
Miller & York Box 1664 Bakersfield Calif
Mobile Drlg & Well Serv Co Inc Box 207 Conroe Tex
Monte Christo Drlg Corp Box 1780 McAllen Tex
Montgomery J S 103 NW 44th St Oklahoma City 18 Okla
R B Montgomery Drlg Inc P O Box 1102 Bakersfield Calif
Moran Bros Inc 1200 Oil & Gas Bldg Wichita Falls Tex
Moran E F Inc 1805 Natl Bk of Tulsa Bldg Tulsa 3 Okla
Moran E W Drlg Co 500 First Natl Bk Bldg Wichita Falls Tex
Moran Oil Prod & Drlg Corp Box 1718 Hobbs N Mex
Morgan Dave Drlg Co Box 820 Blackwell Okla
Morris Pete Drlg Co Box 733 Ada Okla
Mount Dale Drlg Inc 1155 Mercantile Dallas Bldg Dallas 1 Tex
Mountain States Drlg Co Inc 622 Patterson Bldg Denver 2 Colo
Murphy & McKernan Box 169 Pampa Tex
Myers Well Drlg 101 Wible Rd Bakersfield Calif

N

Neal Drlg Co 1507 Esperson Bldg Houston 2 Tex
Nemaha Drlg Co Box 8296 Oklahoma City Okla
Nemaha Oil Co 2206 Mercantile Bk Bldg Dallas Tex
Newton Drlg Co Box 1104 Coalinga Calif
Nichols Drlg Co Box 1032 Duncan Okla
Nicklos Drlg Co 518 First City Natl Bk Bldg Houston 2 Tex
Noah The Petroleum Co 23 Main St Evansville 8 Ind
Norman Drlg Corp 1141 Butternut St Abilene Tex
Norton Drlg Co 542 Nat Bk of Commerce New Orleans 12 La
Nye & Snell Drlg Co 208 Patterson Bldg Denver Colo

O

O'Brien Davey Drlg Co Inc 615 Ft Worth Club Bldg Ft Worth Tex
Oien Oil Corp Box 2235 Cut Bank Mont
Olds & Wrather Drlg Co Box 113 Casper Wyo
Olsen R 2811 Liberty Bk Bldg Oklahoma City 2 Okla
Omohundro W B Box 774 Wichita Falls Tex
Oney Drlg Co Box 425 Graham Tex
Orm Drlg Co 421 M & P Bk Bldg Sherman Tex
Ormand Bros Drlg Co Box 1469 Odessa Tex

P

Pan-Tex Drlg Co 316 Henderson Blvd Kilgore Tex
Parker Drlg Co 418 Natl Bk of Tulsa Bldg Tulsa 3, Okla
Patco Drlg Contr Box 322 Stillwater Okla
Patton Drlg Inc Orpheum Bldg Wichita 6 Kan
Penrod Drlg Co 1320 Mercantile Securities Bldg Dallas 1 Tex
Pep Drlg Co 1002 Main St Mt Vernon Ill
Peters Drlg Co American State Bank Bldg Great Bend Kan
Petro Drlg Co Inc Box 339 Mt Vernon Ill
Pickrell Drlg Co 705 Fourth Natl Bk Bldg Wichita 2 Kan
Pico Drlg Co Box 512 Breckenridge Tex
Pioneer Drlg Co Inc Box 2211 Casper Wyo
Pool Fred Drlg Co 908 Petr Life Bldg Midland Tex
Prairie Drlg Co Inc Box 2068 Casper Wyo
Prime Drlg Co 814-16 Union Center Wichita Kan
Producers Drlg Co Inc 927 Natl Bk of Commerce Bldg New Orleans La
Pyburn Drlg Co Box 4276 Shreveport La

Q

Quad Drlg Co Box 974 Ardmore Okla

R

Raiborn Drlg Co 35 Garden Rd San Angelo Tex
Raymond Drlg Co 410 4th Natl Bank Bldg Wichita 2 Kan
Reading & Bates Inc 1101 Philtower Bldg Tulsa 3 Okla
Reed Drlg Co Inc 1209 Atlas Bldg Tulsa Okla
Rheay & Reynolds Drlg Co 404 Petroleum Bldg Abilene Tex
Rhodes Drlg Co Box 239 Abilene Tex
Rhodes & Hicks Drlg Corp Box 1395 Alice Tex
Rimrock Tidelands Inc Box 896 New Orleans La
Rine R W Drlg Co 420 Union Center Bldg Wichita Kans
Roberson C M Drlg Co 1201 Petroleum Tower Shreveport La
Robinson Drlg Co Box 970 Colorado City Tex
Robinson Bros Drlg Co Box 430 Borger Tex
Rocket Drlg Co 2099 E 27th St Long Beach 6 Calif
Rocky Mountain Drlg Co 6790 N Ventura Ave Ventura Calif
Roden & McRae Drlg Co Box 2286 Casper Wyo
Rowan Drlg Co Inc Drawer 12247 Ft Worth 16 Tex
Ruhl Drlg Co Inc 1621 Bk of Southwest Bldg Houston 2 Tex
Rupp-Ferguson Oil Co 522 Union Center Bldg Wichita Kans
Russell & Russell Drlg & Prod 621 Lindsay St Gainesville Tex
Rutledge Drlg Co Box 2239 Santa Fe N Mex

S

Sabre Drlg Co 222 Hughes Bldg Cushing Okla
Salt Dome Prod Co 737 Texas Natl Bk Bldg Houston 2 Tex
Santa Fe Drlg Co Box 310 Whittier Calif
Santa Rosa Drlg Co Box 633 Apple Valley Calif
Schimmel Drlg Co 2121 Alamo Natl Bldg San Antonio Tex
Schoenfeld-Hunter-Kitch Drlg Co 812 Kennedy Bldg Tulsa 3 Okla
Scooter's Drlg Serv 437 Fortson Shreveport La
Sea Drilling Company 809 Whitney Bldg New Orleans La
Sears H F 424 Petroleum Bldg Amarillo Tex
Seran & Howard Drlg Co Box 110 Okemah Okla
SeRoBee Drlg Co Inc 521-22 Union Natl Bk Bldg Wichita Kans
Service Drlg Co 1307 S Boulder Tulsa Okla
Shaw-Hughes Drlg Co Box 1108 Bristow Okla
Sheets & Walton Drlg Co Box 152 Breckenridge Tex
Sherin Drlg Co Inc 1709 First Natl Bldg Oklahoma City Okla
Shields Drlg Co Inc Box 709 Russell Kans
Shulman Bros Box 191 Vandalia Ill
Simpson CR Drlg Co 2975 Wilshire Blvd Los Angeles 5 Calif
Sitton & Norton Drlg Co 406 Lubbock Natl Bk Bldg Lubbock Tex
Slape Don Drlg Co Box 432 Olney Ill
Slats Honeymoon Drlg Co 1416 Liberty Bk Bldg Okla City Okla
Smith Ray Drlg Co 305 Simons Bldg Dallas Tex
Smith James Drlg Contr Box 33 Mertzon Tex
Smith K Cable Tools 1801 Van Buren Great Bend Kans
Sojourner Drlg Corp Box 679 Abilene Tex
Southeastern Drlg Corp 901 Employers Ins Bldg Dallas Tex
Spradling Drlg Co 401 N Cedar Borger Tex
Sprecher J D Box 299 Casper Wyo
Star Drlg Inc P O Box 1078 Farmington N Mex
Steen Drlg Co 619 West Bldg Houston 2 Tex
Sterling Drlg Box 125 Sterling Colo
Stewart & Gouger Drlg Co 505 Alamo Natl Bldg San Antonio 5 Tex
Stickle Drlg Co 1100 Bitting Bldg Wichita 2 Kans
Stouder Drlg Co 208 SE Riverside Dr Evansville Ind
Sun Drlg Co The 2975 Wilshire Blvd Los Angeles 5 Calif
Sunflower Drlg Co Box 311 Eureka Kan
Sunnyland Contr Co Inc Box 388 Rayne La
Symons Drlg Co 999 Houston Club Bldg Houston 2 Tex

T

T & O Drlg Co Box 461 Gainesville Tex
Taylor Expl Co Inc 2118 Welch Ave Houston 19 Tex
Taylor Virgil Drlg Co Box 776 Gainesville Tex
Temple Drlg Co Inc 320 Indiana Bk Bldg Evansville Ind
Terminal Drlg & Prod Co P O Box 607 Wilmington Calif
Tex-Mex Drlg Co 1211 Fidelity Union Life Bldg Dallas Tex
Thomas & Duffield Drlg Co 809 Citizens Natl Bk Bldg Abilene Tex
Thunderbird Drlg Inc 712 Union Center Bldg Wichita 2 Kan
Tine Gaiser Drlg Co Box 1506 Bakersfield Calif
Trachta Drlg Co Box 67 Muenster Tex
Transit Corp 1516 Liberty Bk Bldg Oklahoma City Okla
Tri-Service Drlg Co Box 1785 Midland Tex
Triton Drlg Co Inc Box 22282 Houston 27 Tex
Troop Drlg Co Box 145 St Elmo Ill
True Drlg Co Drawer 1612 Casper Wyo

U

U & E Drlg Co Box 323 Sullivan Ind
Unit Drlg Co Box 599 Bristow Okla
United Drlg Co Box 986 Longview Tex

V

Varner-Neill Drlg Co Box 1999 Abilene Tex
Viersen & Cochran Box 280 Okmulgee Okla
Viking Drlg Co 102 W Crockett St San Antonio 5 Tex
Virginia Drlg Co Inc 712 Brown Bldg Wichita 2 Kan

W

Wade Drlg Co Inc 813 Gulf Bldg Tulsa Okla
Wagner & Wyant Drlg Co Inc 414 Petroleum Bldg Amarillo Tex
Wakefield Earl F 515 Union Center Bldg Wichita Kans
Walters Drlg Co Inc 4114 McMillan Dallas 6 Tex
Walters Rusty Drlg Co Box 304 Bakersfield Calif
Ward Tommy Drlg Co 2402 Liberty Bk Bldg Oklahoma City Okla
Ward Travis Drlg Co Box 711 Athens Tex
Warren-Bradshaw Drlg Co Nat Bk of Tulsa Bldg Tulsa 3 Okla
Warton Drlg Co Box 2807 Odessa Tex
Webster C B Drlg Co 609 San Jacinto Bldg Houston 2 Tex
Wegener Dick Drlg Co 1820 First Natl Bldg Oklahoma City Okla
Well Drillers Inc 2001 First City Natl Bk Bldg Houston Tex
Wentworth Claude Drlg Inc Box 588 Russell Kan
West Central Drlg Co 717 Citizens Bk Bldg Abilene Tex
Wes-Tex Drlg Co Box 2058 Abilene Tex
Westfall Chester H Drlg Co 1612 First Natl Bk Bldg Tulsa Okla
Westland Drlg Co Box 197 Midland Tex
Wheless Drlg Co Box 1746 Shreveport La
Wilcox Drlg Co Box 365 Covington Okla
Willis Walter W 813 Broadway Mt Vernon Ill
Wilson Fred Drlg Co 1604 Beck Bldg Shreveport La
WLB Drlg Co 6635 Chocolate Bayou Rd Houston 21 Tex
Woolf & Magee Inc Box 635 Tyler Tex

Y

Yates S P Drlg Co 309 Carper Bldg Artesia N Mex

U. S. Contract ROTARY Drilling Rigs

Asterisk (*) indicates rig also available for workover.

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Nichols Drlg Co	77	gas	—	Wisn	—	18,000
Pan-Tex Drlg Co	1	gas	350	Brwstr N-45	400	6,500
Carl J Westlund Inc	3	gas-btne	600	M-CSCO U-15	—	8,500
ALABAMA						
Choctaw County						
Fred Wilson Drlg Co	9	gas	1400	Natl 80-B	800	12,500
ALASKA						
Cape Yakataga						
Clyde Hall Drlg Co Inc	9	dsl	2000	Natl 110	2000+	16,000
Kenai Peninsula						
Coastal Drlg Co	3	dsl	1000	Emsco A-800	1650	13,000
	4	gas	1000	Emsco GB-800	1050	12,000
	5	dsl	1950	Emsco GB-800	1300	14,000
	6	dsl	1200	Emsco G-500	800	9,000
ARIZONA						
Apache County						
Calvert Drlg Inc	15	dsl	260	Ideco H-35	260	5,000
Rutledge Drlg Co	*2	gas-btne	650	Beth M-58	850	10,000
ARKANSAS						
Lafayette County						
Butler-Johnson Inc	3	gas-btne	400	Brwstr N-45	400	7,000
L & N Drlg Co	*1	btne	280	Brwstr N-3	160	3,500
Milton Crow Inc	*6	gas	700	Brwstr N-7	500	6,000
Logan County						
Falcon Seaboard Drlg Co	16	gas	480	Unit U-15	480	8,500
Miller County						
Kern Drlg Co Inc	*1	dsl	247	Emsco 250	260	6,000

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Saline County						
Walters Drlg Co Inc	8	gas	220	Mayhew 1000	220	600/2⅛"
CALIFORNIA						
Newton Drlg Co	1	dsl	350	Ideco	350	4,000
Newton Drlg Co	4	dsl	430	Emsco	350	6,000
Colusa County						
R B Montgomery Drlg Inc	*3	gas	1400	Natl 100	1050	12,000
Fresno County						
Aloha Oil Co	*1	gas	300	Hopper	100	7,000
Graham & Klassen Drlg Co Inc	4	gas	1400	Wisn Titan	1050	11,000
Miller & York Inc	C	dsl	550	Emsco GB-350	450	7,500
R B Montgomery Drlg Inc	*5	gas	1300	Natl 75	1050	11,000
Santa Fe Drlg Co	3	gas	900	Emsco G-500	440	7,500
Glenn County						
Santa Fe Drlg Co	32	dsl	450	Ideco H-40	300	6,000
Inyo County						
Barnes Core Drlg Co	D-11	dsl	225	Custom	225	3,000/3½"
Kern County						
Barnes Core Drlg Co	D-6	dsl	450	Custom	450	5,500/3½"
	D-10	dsl	450	Custom	450	5,500/3½"
Camay Drlg Co	3	gas	1050	Natl 75	950	11,000
	8	gas	1800	Emsco A-800	1800	13,000
H Davis & R H Thompson Co	1	dsl	350	Emsco G-300	350	6,000
Clyde Hall Drlg Co Inc	5	gas-btne	1000	Emsco GB-800	1000	12,000
Coastal Drlg Co	1	dsl	3000	Emsco J-1250	1920	16,000
	2	gas	1200	Emsco J-750	1320	11,000
Armstrong Fowler Inc	2	dsl	300	Natl T-12	250	3,000
K L Kellogg & Sons	18	gas	925	Natl 50	650	7,000
	19	dsl	1200	Natl 75	790	9,500
	25	dsl	1480	Natl 75	1480	9,500
	28	dsl	1350	Natl 100	1100	13,000
	33	gas	1750	Emsco GB-800	1050	12,000
Tine Gaiser Drlg Co	*A	dsl	800	Natl 50	500	7,000
Graham & Klassen Drlg Co Inc	2	gas	1400	Natl 75	1050	10,500
Haney & Williams Drlg Co	*5	gas	1500	Wisn Titan	1000	12,500
Ivy Drlg Co	1	dsl	185	Hopper IG	185	1,500
	2	btne	185	Hopper GF	185	3,000
Knight Drlg Co	2	dsl	1020	Natl CA-50	720	9,000
	3	gas	1450	Beth M-58	750	11,000
Lloyd Drlg Co	*1	dsl	250	Emsco GB-160	200	4,000
Miller & York Inc	1	dsl	300	Frnks Gnt Clpr	225	4,000
	A	dsl	550	Emsco GC-500	900	10,000
	F	dsl	550	Emsco GA-500	600	8,500
	G	dsl	300	Emsco G-36	300	5,500
	H	dsl	300	Emsco GA-250	300	5,500
R B Montgomery Drlg Inc	*1	dsl	1617	Natl 130	1635	18,000
	*2	gas	1350	Natl 110	2025	16,000
Rocky Mountain Drlg Co	9	gas	1500	Natl 125	1500	20,000
	10	dsl	1850	Emsco J-1000	1850	15,000
	13	gas	1550	Emsco J-1250	1550	20,000
	14	gas	1500	Emsco J-1250	1500	20,000
Sun Drlg Co	*5	gas	1530	Natl 110	1530	16,000
Los Angeles County						
Camay Drlg Co	1	gas	1475	Emsco J-1000	1425	13,000
	4	gas	1400	Emsco GA-500	650	8,500
	6	gas	700	Natl 50	550	7,500
F E Gober Drlg Co	*2	gas	450	Natl A-50	450	7,000
	*3	dsl	450	Ideco 700	600	8,000
Haney & Williams Drlg Co	*1	dsl	450	Wisn Gnt	300	5,000
	*2	gas	700	Natl 50	700	7,500
	*3	gas	1350	Natl 75	1350	10,000
	*6	AC elec	800	Natl 75	1200	11,000
Fred Johnson Drlg Co	1	gas	1071	Emsco J-1000	714	9,500
	3	gas	1500	Emsco J-1000	1125	12,000
	4	DC elec	1050	Natl 50	600	7,500
K L Kellogg & Sons	29	gas	1370	Natl 75	700	9,500
Rocky Mountain Drlg Co	6	gas	1550	Emsco J-1000	1550	15,000
	7	gas	1200	Natl 100	1110	15,000
C R Simpson Drlg Co	2	gas	700	Natl 50	520	8,000
Terminal Drlg & Prod Co	*4	gas	630	Ideco H-40-D	450	6,000
	*12	gas	320	Ideco H-30	190	4,000
Macrate Prod Co	2	dsl	300	Ideco HD-30	190	3,500
	7	dsl	350	W-M M41-A2	350	5,000
	8	dsl	350	W-M 15-40	300	4,500
Rocket Drlg Co	1	gas-btne-prop	555	Emsco G-300	350	4,500
Santa Fe Drlg Co	26	gas	1200	Wisn Titan	900	10,000
	29	elec	1000	Natl 3410-½ FE	800	15,000
Sun Drlg Co	*2	elec	850	Natl 110	500	11,000
	*4	elec	850	Natl 110	500	11,000

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Kings County						
K L Kellogg & Sons	27	gas	2000	Natl 100	1050	13,000
McDonald Island						
Newton Drlg Co	2	dsl	350	Ideco	350	5,000
Modoc County						
Myers Drlg Co	*9	dsl	671	Hopper	671 Twin	5,000
Napa County						
Armstrong Fowler Inc	3	dsl	—	Wisn Mogul	—	5,000
Obispo County						
Tine Gaiser Drlg Co	*B	dsl	1150	Emsco GB-500	700	9,000
Orange County						
H Davis & R H Thompson Co	2	dsl	350	Emsco GA-250-T	350	6,000
C R Simpson Drlg Co	1	gas	700	Natl 50	432	7,000
Terminal Drlg & Prod Co	*1	gas	990	Natl A-50	700	8,500
Sacramento County						
Rusty Walters Drlg Co	2	dsl	360	Wisn Mogul	360	7,000
San Bernardino County						
Santa Rosa Drlg Co	1	prop-gas	155	Kargo King	155	3,000
				Kargo King	130	2,000
Santa Barbara County						
Santa Fe Drlg Co	28	gas	1200	Natl B-80	1350	12,000
Solano County						
R B Montgomery Drlg Inc	*6	dsl	1000	Natl 75	600	10,000
Santa Fe Drlg Co	34	gas	1050	Natl B-80	900	10,000
Ventura County						
Caldrill Inc	U	gas	1500	OWS 96	1600	16,000
	T	gas	1600	OWS 96	1400	16,000
Camay Drlg Co	9	gas	1900	Natl 130	1900	18,000
Graham & Klassen Drlg Co Inc	3	gas	1500	Natl 75	1200	11,000
K L Kellogg & Sons	7	gas	2240	Natl 100	1050	13,000
	23	gas	2090	Natl 75	790	9,500
	31	gas	1580	Natl 125	1050	16,000
	32	gas	1400	Natl 75	1050	9,500
	34	gas	2475	Natl 125	2475	16,000
	36	gas	2475	Natl 125	2475	16,000
Rocky Mountain Drlg Co	1	gas	1200	Natl 75	900	11,000
	2	gas	1200	Natl 75	900	11,000
	3	gas	1200	Natl 100	900	14,000
	4	gas-dsl	1550	"Oilwell" 96	1850	20,000
	5	gas	1850	"Oilwell" 96	1850	20,000
	8	gas	1400	Natl 125	1750	20,000
	12	gas	1850	Natl 125	1850	20,000
	15	gas	1200	Emsco J-750	900	11,000
Santa Fe Drlg Co	25	gas	1200	Natl 55	900	10,000
Sun Drlg Co	1	gas	2430	Natl 125	2430	20,000
Terminal Drlg & Prod Co	6	dsl	1000	Emsco GC-500	750	10,000
	*18	dsl	600	Ideco 525	600	8,000
United Drlg Co	*1	nat gas	450	Emsco	450	6,000
Yolo County						
Knight Drlg Co	1	dsl	1020	M-CSCO U-35D	500	8,000
COLORADO						
Walters Drlg Co Inc (Dallas)	4	gas	130	Mayhew 1000	130	600/2⅛"
Adams County						
Exeter Drlg Co	2	btne	320	Emsco GA-250	250	6,000/4"
Baca County						
Moran Bros Inc	15	gas	400	Natl T-20	390	6,000
Garfield County						
B F Allison Drlg Co	4	gas	900	N-75	900	12,000
Camay Drlg Co Rocky Mt Div	6	dsl	260	Johnson	450	5,000
Mountain States Drlg Co Inc	6	dsl	600	Natl 50	—	7,500
Jackson County						
R L Manning Co	7	gas-btne	750	Emsco G-500	750	8,000
Kiowa County						
R W Rine Drlg Co	2	dsl	520	Brwstr N-7	600	10,000
Larimer County						
Mountain States Drlg Co Inc	17	dsl	540	Natl T-32	—	6,000
Logan County						
Exeter Drlg Co	5	dsl	300	Natl T-32	300	6,000
Garvey Drlg Co	12	dsl	300	Wisn Gnt	320	6,000/3½"
Lewis Bros Inc	1	dsl	376	Crdwll J-450	476	7,500
	2	btne	360	M-CSCO U-15	460	6,500
Mesa County						
Camay Drlg Co Rocky Mt Div	1	gas	775	M-CSCO U-15	600	8,500
Moffat County						
Delta Drlg Co	18	dsl	600	Natl 75	650	9,500
Kerr-McGee Oil Industries Inc	31	gas	1000	Natl 100	1680	15,000
Will I Lewis Drlg Co	6	dsl	1600	M-CSCO U-20	1600	14,000
Nye & Snell Drlg Co	1	gas	550	Unit 15	700	8,000
Pioneer Drlg Co Inc	*3	dsl	800	Emsco GA-500	700	9,000

Now- 12 All-steel Sizes

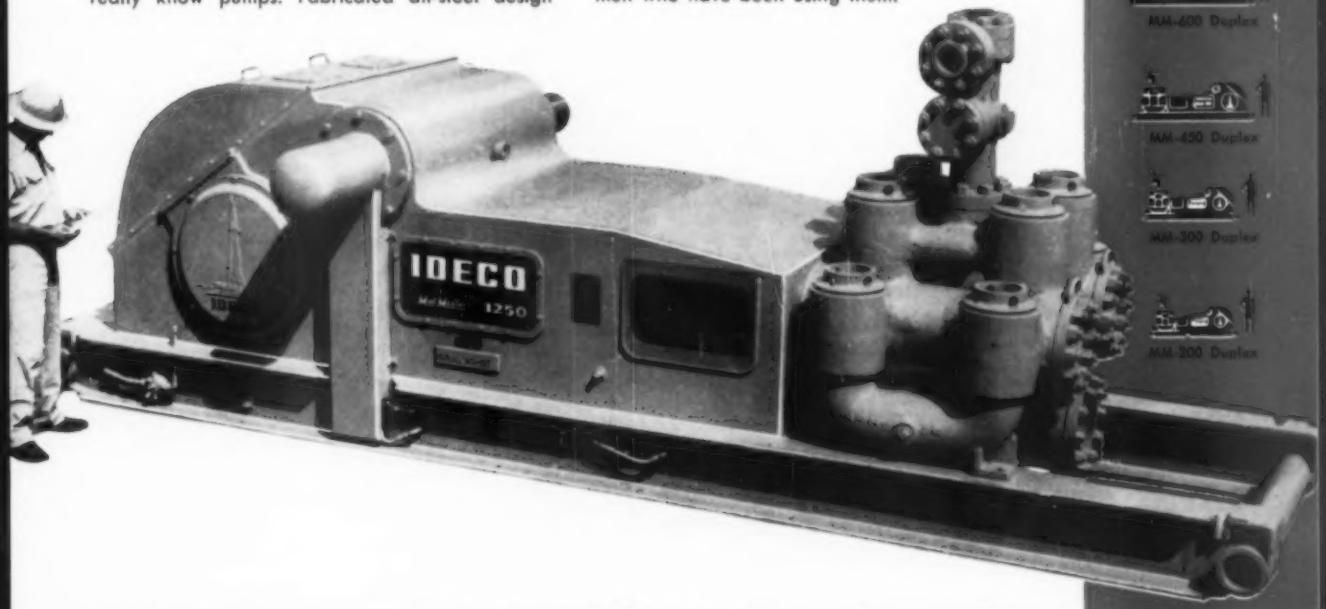
IDECO MUD PUMPS

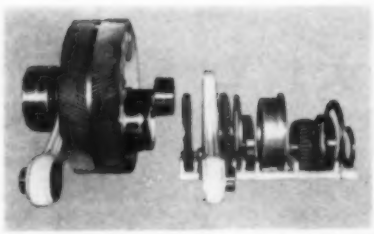
Power pumps that deliver a high pressure punch — Ideco builds them in twelve sizes, duplex and triplex, from 200 to 1250 H.P.

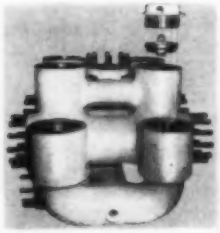
These all-steel pumps feature precision-built power ends and streamlined one-piece fluid ends which work together as a tough team to help you show more profit in today's competitive market.

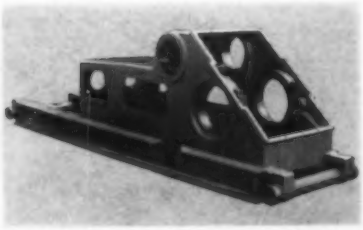
Ideco pumps are a product of the application of years of engineering experience by men who really know pumps. Fabricated all-steel design assures minimum vibration . . . heat treated pinion shaft and Falk herringbone main gear can be reversed for double life . . . double-row Timken tapered roller bearings assure durability. Threaded valve pot covers speed valve servicing and reduce crew work. Gamma ray and strain gauge tests prove the strength of every part.

So remember, when you think of mud pumps . . . think of Ideco — you'll get the best. Just ask the men who have been using them.









Top quality components such as Timken bearings and Falk herringbone gears assure longer, trouble-free performance. Streamlined, one-piece cast steel fluid ends are designed for highest volumetric efficiency and tested to twice rated operating pressures. Fabriform frames are stronger and lighter in weight.

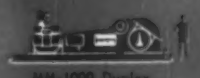
There is no Substitute for Quality

IDECO

P. O. BOX 1331
DALLAS, TEXAS

DRESSER
INDUSTRIES, INC.

MM-1250 Duplex


MM-1000 Duplex

MM-700 Duplex

MM-600 Duplex

MM-450 Duplex

MM-300 Duplex

MM-200 Duplex

FM-1250 Triplex

FM-1000 Triplex

T-800-C Triplex

FM-600 Triplex

T-660-C Triplex

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Montezuma County						
Moran Bros Inc	7	gas	1100	Wisn Gnt	1000	12,000
Morgan County						
Allison Drlg Co	2	gas	675	U-15	675	8,500
Rio Blanco County						
Mountain States Drlg Co Inc	4	gas-dsl	600	Emsco GB-500	—	9,000
Nye & Snell Drlg Co	3	gas	600	Wisn Atlas	800	11,000
Routt County						
R L Manning Co	12	gas-btne	650	Emsco GA-350	450	7,000
Roden & McRae Drlg Corp	1	dsl	625	Emsco GA-350	570	7,000
San Miguel County						
Kerr-McGee Oil Industries Inc	4	gas	885	Natl 75	832	11,500
R L Manning Co	6	gas-btne	900	Emsco GB-800	1125	11,000
Washington County						
Allison Drlg Co	5	gas	450	Frnks 137 DT	300	6,000
FLORIDA						
Collier County						
Rowan Drlg Co Inc	32	gas-btne	1200	Natl 100	1110	12,000
Santa Rosa County						
Zach Brooks Drlg Co	7	dsl	1350	Emsco J-1100	1350	14,000
ILLINOIS						
Christian County						
U & E Drlg Co	*1	dsl	450	Frnks 4500	450	3,500
Clark County						
Don Slape Drlg Co	4	dsl	300	Brwstr N-4	245	4,500
Clay County						
Claypool Drlg Co	2	btne	300	Natl T-12	185	4,000
Ted Lindsay	3	dsl	220	Ideco H-30	160	4,000
Shulman Bros	1	dsl	330	Crdwll S-350	—	5,500
	2	dsl	330	Crdwll L	—	3,500
Don Slape Drlg Co	5	btne	360	Natl T-12	260	4,500
Clinton County						
Conrey Drlg Co	1	gas	140	Wisn Super	140	2,000/3½"
Franklin County						
W L Dillier Inc	5	dsl	—	Natl T-20	212	3,500
Petro Drlg Co Inc	1	dsl	450	Brwstr N-4	300	6,500
Gallatin County						
Burns Drlg Co	1	dsl	440	M-CSCO U-15	440	7,500
Pep Drlg Co	1	dsl	425	Beth Breeze	300	5,000
Hamilton County						
C E Brehn Drlg & Prod	3	dsl	302	N-45 Brwstr	302	6,000
E F Moran Inc	1	btne	300	Brwstr N-4	600	6,000
Jasper County						
Calvert Drlg Inc	12	dsl	260	Ideco H-30	260	4,500
W L Dillier Inc	1	dsl	—	Natl T-12	212	3 000
Jefferson County						
Pep Drlg Co	2	dsl	425	Ideco H-35	300	6 000
Kankakee County						
Moran Bros Inc	17	dsl	400	Wisn Gnt	400	6,000
La Salle County						
Moran Bros Inc	14	dsl	350	Natl T-12	350	4,500
Lawrence County						
W L Dillier Inc	2	gas	—	Failing 2500	130	2,000
Macon County						
W L Dillier Inc	3	gas	—	Failing 2500	130	2,000
Marion County						
Conrey Drlg Co	2	dsl	175	Wisn Super	175	2,500/3½"
McLean County						
W L Dillier Inc	4	gas	—	Failing 2500	130	2,000
Richland County						
Woody Jones Drlg Co	1	dsl	240	M-CSCO U-34	230	4,500
Don Slape Drlg Co	2	dsl	240	M-CSCO U-34	230	4,500
Sangamon County						
Troop Drlg Co	1	dsl	—	Natl T-20	220	4,500
Wayne County						
Ted Lindsay	2	dsl	300	Natl T-16	—	5,500
White County						
Lohmann-Johnson Drlg Co Inc	7	dsl	300	Crdwll S	440	4,500
E F Moran Inc	2	btne	300	Natl T-12	300	4,500
	4	btne	300	Brwstr N-3	300	3,500/3½"
INDIANA						
Cass County						
Stouder Drlg Co	*2	gas	210	Natl T-12	180	3,500
Gibson County						
Lohmann-Johnson Drlg Co Inc	6	btne	300	Crdwll S	440	4,500
The Noah Petroleum Co	1	dsl	300	Brwstr N-4	300	5,500
Greene County						
Stouder Drlg Co	*1	gas	210	Natl 40	180	4,000
Knox County						
Gwaltney Drlg Inc	2	gas-prop	200	Crdwll	165	3,000
Perry County						
Gwaltney Drlg Inc	3	gas	100	—	100	1,500
Pike County						
Gwaltney Drlg Inc	1	dsl	200	Natl T-12	165	3,000
Posey County						
Kendall-Davis Drlg Co Inc	1	dsl	300	Wisn Mogul	300	4,000
E F Moran Inc	3	btne	300	Crdwll S	300	4,000
Sullivan County						
U & E Drlg Co	*2	dsl	450	Natl T-12	450	4,500
Vanderburgh County						
Big Seven Drlg Co	1	dsl	300	Emsco GB	300	4,500
IOWA						
Dallas County						
Kirby Oil Ind Inc	—	dsl	400	Brwstr N-4	400	4,500
Mills County						
Kirby Oil Ind Inc	—	dsl	400	Mayhew 3000	200	3,000
KANSAS						
Barber County						
Patton Drlg Co Inc	*2	dsl	450	Natl 50	450	6,500
Barton County						
Bennett & Roberts Drlg Co	*1	dsl	250	Emsco GB-250	250	5,000
Brack Drlg Co Inc (Colo)	*1	dsl	—	W15 Unit	330	5,700
Peters Drlg Co	*674	dsl	—	Crdwll RL	200	—
Raymond Oil Co Inc	1	dsl	600	Wisn Mogul	600	4,000
Cheyenne County						
John O Farmer Inc	*5	gas	400	Natl 50	400	8,000
Clark County						
Patton Drlg Co Inc	*1	gas	450	Natl 50	450	6,500
Decatur County						
Peters Drlg Co	*673	btne	—	Crdwll RL	145	—
Ellis County						
Transit Corp	3	dsl	280	Emsco	280	4,500
Finney County						
Helmerich & Payne Inc	46	gas	500	Emsco GB-500-52	700	9,000
Service Drlg Co	*2	gas	296	U-34	200	6,000
Ford County						
Garvey Drlg Co	10	dsl	175	Wisn Gnt	296	5,000
Prime Drlg Co	3	dsl	275	Unit U-34	285	4,500
Graham County						
Empire Drlg Co (Kans)	1	dsl	300	Natl T-32	300	5,000
Kimbark Expl Co	4	dsl	200	Unit U-35A	300	5,500
Grant County						
Moran Bros Inc	18	gas	650	M-CSCO U-15	600	7,500
Hamilton County						
Service Drlg Co	*1	dsl	180	U-34	180	4,500
Haskell County						
Garvey Drlg Co	6	dsl	276	M-CSCO U-15	640	8,500
	22	dsl	300	Wisn Mogul 42	450	7,000
R W Rine Drlg Co	5	gas-btne	520	Brwstr N-55	550	8,000
Hodgeman County						
Pickrell Drlg Co	*1	dsl	450	Unit U-15	450	5,500
Kingman County						
Capitt Drlg Inc	2	dsl	300	Beth S-45	285	5,000
Garvey Drlg Co	11	dsl	175	Wisn Gnt	296	5,000
	14	dsl	175	Wisn Gnt	296	5,000
Lohmann-Johnson Drlg Co Inc	3	btne	300	Natl 80	450	5,500
Pickrell Drlg Co	10	dsl	540	Ideco H-40	—	6,000
Prime Drlg Co	2	dsl	300	Beth S-45	300	5,000
Stickle Drlg Co	*6	dsl	300	Brwstr N-45	300	6,500
Thunderbird Drlg Inc	2	dsl	285	Natl T-32	285	5,500
Kiowa County						
Capitt Drlg Inc	6	dsl	410	Beth C-50	500	7,500
Marion County						
Buick Drlg Inc	2	dsl	250	Wisn Gnt	325	5,000
Capitt Drlg Inc	5	gas	300	Beth FC-200	300	4,000
SeRoBee Drlg Co Inc	1	dsl	—	Crdwll K	150	—
Sunflower Drlg Co Inc	*1	dsl	175	Brwstr N-3	320	3,500
McPherson County						
Mallard Drlg Co Inc	*1	dsl	—	G-300	180	4,000
SeRoBee Drlg Co Inc	*2	gas-btne	300	Crdwll RL	250	4,500
Meade County						
Bennett & Roberts Drlg Co	2	dsl	250	Emsco 250	250	6,000/3½"
	3	dsl	500	Emsco GA-500	500	8,000
Capitt Drlg Inc	3	dsl	325	Beth C-50	500	7,500
D & M Drlg Co Inc	1	gas-btne	550	Natl 50	550	8,000
Kern Drlg Co Inc	*2	gas	350	Emsco 350	350	7,500
Stickle Drlg Co	*5	dsl	300	Ideal T-32	300	6,000
Earl F Wakefield	4	gas-btne	750	Wisn Gnt Rdair	750	9,500
Tommy Ward Drlg Co	*1	gas	—	Unit U-15	—	—
Warren-Bradshaw Drlg Co	*56	gas-btne	—	Unit U-15	750	8,500
Claude Wentworth Drlg Co Inc	*4	dsl	400	Unit U-15	500	8,000
	*10	dsl	400	Emsco 500	500	8,000

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Morton County						
Holm Drlg Co	4	dsl	520	Wlsn Gnt	300	6,000
Ness County						
Rupp-Ferguson Oil Co	1	dsl	300	Ideco H-35	300	5,200
Phillips County						
Stickle Drlg Co	*4	dsl	300	Ideco H-35	300	5,000
Earl F Wakefield	1	dsl	440	Wlsn Mogul Rdair	440	5,000
Rawlins County						
John O Farmer Inc	*3	gas	330	Guffy Spad	330	7,000
Claude Wentworth Drlg Co Inc	*2	gas-dsl	240	Crdwll "S"	175 gas	5,000
	*5	dsl	400	Unit U-15	500	8,000
Red Willow County						
Mast Drlg Inc	2	dsl	185	Natl T-32	250	5,500
Rice County						
Donald T Ingling	4	dsl	225	Brwstr N-4	225	5,500
Isern Drlg Co	*1	dsl	—	Unit U-15	—	6,500
Sterling Drlg Co	*1	dsl	370	Emsco G-300	370	4,500
	*4	gas	450	Unit U-15	450	5,500
Thunderbird Drlg Inc	1	btne	225	Crdwll Model S	225	4,500
Rooks County						
Transit Corp	2	dsl	280	Emsco	280	4,500
	4	dsl	280	Emsco	212	4,500
Virginia Drlg Co Inc	*1	dsl	G D	Natl 32	400	5,000
Rush County						
John O Farmer Inc	*4	dsl	400	Ideco H-30	400	7,000
Garvey Drlg Co	9	dsl	175	Wlsn Gnt	296	5,000
Russell County						
Shields Drlg Co Inc	*2	dsl	300	Beth C-50	300	8,000
	*3	dsl	300	Wlsn Gnt	400	6,000
K Smith Cable Tools	*Wlkr Neer	gas	—	S-32	140	4,800
Seward County						
D & M Drlg Co Inc	2	gas-btne	900	M-CSCO U-15	900	9,000
Lynn Drlg Co	4	gas-btne	600	Natl 50	600	8,000
Sheridan County						
John O Farmer Inc	*1	gas	330	Guffy Spad	330	7,000
Stafford County						
Chief Drlg Co Inc	1	gas (prop)	250	Emsco 300	250	4,800
Garvey Drlg Co	3	dsl	175	M-CSCO U-15	296	5,000
	15	dsl	175	Wlsn Gnt	296	5,000
Virginia Drlg Co Inc	*2	dsl	G D	Natl 50	400	7,000
Stevens County						
Earl F Wakefield	7	gas-btne	220	Continental Emsco GB-160-T	250	4,500
Sumner County						
Garvey Drlg Co	8	dsl	175	Wlsn Gnt	296	5,000
Peters Drlg Co	*241	dsl	—	Crdwll KL	300	—
Earl F Wakefield	3	dsl	440	Wlsn Gnt Rdair	440	6,000
Claude Wentworth Drlg Co Inc	*1	gas	200	Crdwll "S"	200	5,000
KENTUCKY						
Henderson County						
Temple Drlg Co Inc	12	dsl	300	Crdwll S	440	4,500
Hopkins County						
E F Moran Inc	5	btne	145	Failing 2500	—	2,500/3½"
McLean County						
Kendall-Davis Drlg Co Inc	2	dsl	300	Crdwll S	300	4,000
Metcalf County						
Taylor Expl Co Inc	8	btne	—	Failing	—	2,000
LOUISIANA						
Falcon Seaboard Co	52	dsl-elec	1250	Beth MC-1013	1250	20,000
Acadia Parish						
Circle Drlg Co Inc	3	gas-elec	1500	Ideco Big Gnt	2100	15,000
Clegg & Hunt	1	stm	—	Emsco 10	—	15,000
Falcon Seaboard Drlg Co	3	stm	625	BIW Drdnt	625	17,000
Kilroy Drlg & Prod Co	4	gas	1100	Ideco 7-11	1125	12,000
Mac Drlg Co	3	stm	600	Natl 23-9-FE	1000+	20,000
Ruhl Drlg Co Inc	*1	gas-btne	600	Brwstr N-7	600	10,000
Sunnyland Contr Co Inc	7	dsl	—	Ideco H-40	450	8,000
	8	gas-gaso	—	Crdwll D	312	8,000
	9	dsl	—	Crdwll D	450	8,000
Fred Wilson Drlg Co	10	gas	1050	Natl 55	800	10,500
Allen Parish						
Penrod Drlg Co	2	dsl	800	Brwstr N-45	550	6,500 or 10,500 w/ 2⅛" DP
Assumption Parish						
Delta Drlg Co	35	gas-btne	1200	Emsco J-1100	1200	15,000
	37	dsl	900	Beth MC-950	1400	15,000
Gracey-H Ilums Corp	Bge 2	stm	1200	Natl 23-9-FE	1200	15,000
Stewart & Gouger Drlg Co	1	dsl	1500	Natl 130	1700	20,000
Beauregard Parish						
Comet Drlg Co	2	dsl	1000	Natl 75	750	10,000
Symons Drlg Co	U-15	gas	500	M-CSCO U-15	650	10,000

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Bienville Parish						
Butler-Johnson Inc	2	gas-btne	450	Brwstr N-55	450	8,000
Jet Drlg Co Inc	2	dsl	600	Brwstr N-7	600	9,000
Milton Crow, Inc	*3	dsl	800	Brwstr N-7	600	8,000
Penrod Drlg Co	26	gas-btne	1250	M-CSCO U-20	1400	14,000
Bossier Parish						
Tex-Mex Drlg Co	8	stm	—	—	1000+	9,000
Wheless Drlg Co	1	gas-btne	510	Brwstr N-45	450	7,500
Woolf & Magee Inc	7	gas-btne	800	Beth MC-450	800	11,000
Caddo Parish						
Clegg & Hunt	9	btne-gas	—	Natl 50-A	—	9,800
Kendrick Bros Drlg Cont	*1	btne	185	Brwstr N-14	185	4,500
L & N Drlg Co	*2	btne	280	Wlsn Super	120	2,500
Tex-Mex Drlg Co	11	stm	—	—	1000+	12,000
Calcasieu Parish						
Circle Drlg Co Inc	4	gas-btne	800	Brwstr N-75	960	11,000
Comet Drlg Co	4	dsl	750	Brwstr N-7	500	10,000
Delta Drlg Co	21	gas-btne	800	Natl 75	650	9,500
Penrod Drlg Co	16	gas-btne	1825	Emsco J-1400	1650	18,000
Cameron Parish						
Brewster-Bartle Drlg Co Inc	10	dsl	—	"Oilwell ' 76	—	11,000
Clegg & Hunt	8	dsl	—	—	1275	18,000
Delta Drlg Co	14	stm	900	Ideco Big Gnt	1690	15,000
	20	gas-btne	1520	Emsco J-1250	1250	15,000
Harry Edwards Drlg Co	Bge 1	dsl	600	Natl 75	800	10,000
	Bge 12	dsl-elec	3000	Ideco Big Gnt	3000	20,000
A W Eggleston Inc	1	gas-btne	900	Ideco PR-800	900	11,000
	4	gas-btne	800	Natl 60-A	800	10,000
Falcon Seaboard Drlg Co	2	stm	600	Ideco Big Gnt	600	20,000
Penrod Drlg Co	Bge 41	dsl	950	Emsco J-1100	1100	14,000
Southeastern Drlg Co	Bge 9	—	2200	"Oilwell" 96	2200	16,000
C B Webster Drlg Co	1	dsl	1650	"Oilwell" 96	1800	17,000
Wheless Drlg Co	Bge 7	dsl	2000	Natl 130	1900	18,000
Wheless Drlg Co	Bge 12	gas-btne	1085	Natl 80	1300	12,000
Catahoula Parish						
Scooter's Drlg Serv	2	dsl	300	Brwstr N-4	300	4,500
Woolf & Magee Inc	11	gas-btne	275	Beth S-45	275	10,000/2⅛"
Claiborne Parish						
An-Son Drlg Co	*5	gas	1050	Natl 80B	1185	12,500
Kern Drlg Co Inc	*3	dsl	247	Emsco 250	260	6,000
Maritzky & Bibby	1	gas	330	Brwstr	185	5,000
	2	gas	330	Crdwll	145	3,000
C M Roberson Drlg Co	1	gas-btne	400	Brwstr N-45	400	7,300
Woolf & Magee Inc	5	gas-btne	800	Beth MC-450	800	11,000
Concordia Parish						
Fortenbery Drlg Co	4	dsl	300	Ideco H-30	250	7,000
De Soto Parish						
Butler-Johnson Inc	4	gas	500	Brwstr N4	350	6,500
Evangeline Parish						
Nicklos Drlg Co	14	gas-btne		Natl 75	1000	12,000
Franklin Parish						
Scooter's Drlg Serv	4	dsl	300	Brwstr N-45	500	6,000
Iberia Parish						
Delta Drlg Co	19	stm	1200	Natl 34-10-FE	1690	15,000
Nicklos Drlg Co	11	stm		Natl		17,000
Wheless Drlg Co	4	stm	1000+	Emsco UBLS-54	1000+	12,000
Iberville Parish						
Circle Drlg Co Inc	7	gas-btne	1500	Ideco 7-11	1200	15,000
A W Eggleston Inc	2	gas-btne	900	Ideco PR-800	900	12,000
C B Webster Drlg Co	3	gas	1250	Emsco J-1250	1300	15,000
Fred Wilson Drlg Co	7	gas	1400	Natl 80-B	800	12,500
Fred Wilson Drlg Co	11	gas	1050	Natl 55	800	10,500
Jackson Parish						
Butler-Johnson Inc	1	gas-btne	650	Brwstr N-75	1005	10,000
Milton Grow Inc	4	gas	900	Brwstr N-75	750	11,000
Jefferson Parish						
Delta Drlg Co	31	gas-btne	1020	Emsco J-1000	1260	13,000
	45	stm		Emsco UH-54	1000	15,000
Rowan Drlg Co Inc	30	dsl	1545	Emsco A-1500	1545	20,000
	Bge 21	dsl-elec	1000	Emsco ECA	1920	12,000
	Bge 26	dsl	1325	Natl 100	1545	14,000
Jefferson Davis Parish						
Delta Drlg Co	5	gas-btne	900	Natl 100	800	12,000
Harry Edwards Drlg Co	6	stm	350	BIW 12	4-150 Boilers	16,500
	7	stm	350	BIW 12	4-150 Boilers	16,500
Penrod Drlg Co	6	dsl	2000	Natl 110	1350	16,500
Steen Drlg Co	2	stm	600	Emsco ECA		16,000
Lafayette Parish						
Falcon Seaboard Drlg Co	1	stm	600	IDECO Big Gnt	600	20,000

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Lafourche Parish						
Brewster-Bartle Drlg Co Inc	6	dsl		"Oilwell" 96	1500	
Continental Rigs Inc	3	dsl	1800	Ideco M-1	1800	13,000
Crawford Drlg Co	2	stm	1000	ECA Emsco	1000	15,000
Delta Drlg Co	47	dsl	1700	Ideco PR-1050	1600	17,000
Dixie Drlg Co Inc	3	dsl	3300	Beth B-3661	3000	16,000
Falcon Seaboard Drlg Co	12	stm	600	Natl 23-10½	600	20,000
	44	dsl	1250	Beth B-3661	1250	22,500
Nicklos Drlg Co	12	stm		Natl		17,000
Norton Drlg Co	Bge 4	dsl	1600	Emsco J-1250	1600	17,000
	Bge 5	dsl	1600	"Oilwell" 96	1600	17,000
Penrod Drlg Co	Bge 42	dsl	2000	Brwstr N-12A	1150	18,000
Rowan Drlg Co Inc	Bge 1	dsl-elec	1600	Emsco ECA	2475	18,000
	Bge 3	dsl-elec	2150	Emsco EDA	3455	20,000
	4	gas-btne	900	Natl 75	1149	11,000
Southeastern Drlg Co	Bge 14		1600	"Oilwell" 96	1600	16,000
Sunnyland Contr Co Inc	11	dsl		Ideco H-750	520	11,000
Wheless Drlg Co	Bge 11	gas-btne	1085	Emsco J-1250	1400	13,500
LaSalle Parish						
Justiss-Mears Oil Co Inc	5	gas	280	Model S Crdwll	225	3,700
	6	dsl	380	Emsco GA-250	300	6,000
Lincoln Parish						
Arrow Drlg Co	16	gas	840	Natl 125		14,000
	18	gas	1260	Emsco 1250		14,000
Jet Drlg Co Inc	5	gas-btne	700	Emsco 800	800	10,500
Wheless Drlg Co	2	gas-btne	820	Brwstr N-7	800	9,500
	13	gas-btne	820	Emsco J-750	850	10,500
Morgan City						
Rimrock Tidelands Inc	15	dsl	2000	Brwstr N-12-A	2000	20,000
Ouachita Parish						
Dixilyn Drlg Corp	7	dsl	2475	Natl 110	2475	15,000
The H & S Drlg Co	*1	gas-gaso btne	1235	Wilson Titan	1000	12,000
	*2	gas-btne	1324	Brwstr N-95	1000	14,000
Pyburn Drlg Co	1	dsl	500	Ideco-M-750	600	9,000
Plaquemines Parish						
Brewster-Bartle Drlg Co Inc	1	dsl		"Oilwell" 96	1500	16,000
	3	dsl		"Oilwell" 96	1500	16,000
	11	dsl		"Oilwell" 96	1500	16,000
Circle Drlg Co Inc	5	gas-btne	1500	Brwstr N-12	1440	15,000
Clegg & Hunt	Bge 11	dsl-elec	2600	Ideco 2500	1900	23,000
Clinch Drlg Co	*1	dsl	425	Emsco GA-350	425	7,500
Continental Rigs Inc	*6	dsl	800	Emsco BG-500	800	9,000
	8	dsl	2200	Beth 1013	2200	20,000
Dillard-Waltermire Inc	8	stm	1200	Natl 34-10FE	1500	16,000
Penrod Drlg Co	Bge 40	dsl	2000	Brwstr N-12-A	1725	18,000
Producers Drlg Co Inc	*1	dsl	2400	U1220	2400	20,000
Rowan Drlg Co Inc	Bge 18	stm	1800	Emsco ED	750	18,000
Wheless Drlg Co	Bge 9	dsl	1700	Natl 130	1470	18,000
	Bge 15	dsl	1975	Natl 130	1900	18,000
Richland Parish						
Lunsford Drlg Co	1	LPG	185	Brwstr N-3	145	4,000
Wheless Drlg Co	10	gas-btne	1020	Natl 100	1200	13,000
Sabine Parish						
Hilburn Industries Inc	2	gas	550	Wisn	550	10,000
St Bernard Parish						
Producers Drlg Co Inc	*2	dsl	2200	U914B	1800	18,000
St Charles Parish						
Sea Drlg Corp	*5	dsl	2500	M-CSCO	2500	18,000
St John the Baptist Parish						
Nicklos Drlg Co	15	gas-btne		Natl 80	1000	13,000
St Landry Parish						
Pernie Bailey	1	gas	650	Brwstr N-75		11,000
	2	gas	800	M-CSCO U-40		11,000
A W Eggleston Inc	3	dsl	1500	Ideco PR-1050	1500	14,000
St Martin Parish						
Dixie Drlg Co Inc	2	dsl	2000	Beth Tornado	1500	16,000
Kilroy Drlg & Prod Co	1	gas	1200	"Oilwell" 96	1350	15,000
St Mary Parish						
Brewster-Bartle Drlg Co Inc	2	dsl	—	"Oilwell" 96	1500	16,000
	8	dsl	—	"Oilwell" 96	1500	16,000
	9	dsl	—	"Oilwell" 96	1500	16,000
Falcon Seaboard Drlg Co	53	dsl-elec	1250	Beth MC-103	1250	20,000
Kerr-McGee Oil Industries Inc	39	dsl	1500	"Oilwell" 96	1560	15,000
	43	dsl	1880	Emsco J-1000	1500	15,000
Nichols Drlg Co	18	gas-btne	—	Natl 110	1600	17,000
Penrod Drlg Co	17	gas-btne	1450	Brwstr N-12-A	1650	18,000
	Bge 47	dsl-elec	2500	Emsco EDA	1250	20,000
Rowan Drlg Co Inc	Bge 6	dsl-elec	1200	Emsco ED	2800	18,000
	Bge 13	dsl-elec	1700	Emsco FCA	2700	18,000
	Bge 14	dsl-elec	1600	Emsco ECA	2325	18,000
Salt Dome Prod Co	*14	dsl	—	Natl 55	850	10,000
Southeastern Drlg Co	Bge 21	—	2200	"Oilwell" 96	2200	16,000
C B Webster Drlg Co	5	stm	1350	Emsco ECA-10½	1200+	15,000
	Bge 6	dsl	2000	Emsco J-1400	2400	17,000
Wheless Drlg Co	Bge 14	dsl	1700	Emsco J-1400	1470	18,000
Tensas Parish						
Arrow Drlg Co	1	gas	860	Beth 810	—	12,000
B M Hester	1	btne	325	Natl T-20	2000	6,000
Justiss-Mears Oil Co Inc	8	dsl	350	Emsco GA-500	600	9,500
Scooter's Drlg Serv	3	dsl	600	Brwstr N-55	600	6,000
Terrebonne Parish						
Brewster-Bartle Drlg Co Inc	5	dsl	—	"Oilwell" 96	1500	16,000
	7	dsl	—	"Oilwell" 96	1500	16,000
	14	dsl	—	Natl 125	—	16,000
Continental Rigs Inc	*4	dsl	1200	Emsco J-750	1200	12,000
	5	dsl	3000	Emsco EDA	3000	20,000
Crawford Drlg Co	*1	dsl	500	Brwstr N-7	500	9,000
Delta Drlg Co	17	gas-btne	1020	Emsco J-1100	1300	15,000
	25	gas-btne	1520	Emsco J-1250	1250	15,000
	32	stm	1200	Ideco Big Gnt	1690	15,000
Delta Marine Drlg Co	*4	dsl-elec	2500	Emsco EDA	1400	15,000
	*3	dsl	1200	Beth AC-702	1500	15,000
Dixie Drlg Co Inc	1	dsl	1500	Beth 1013	1500	16,000
Gracey-Hellums Corp	Bge 4	dsl	1775	Emsco A-1500	1900	20,000
Nicklos Drlg Co	23	gas-btne	—	Natl 125	2025	20,000
Norton Drlg Co	Bge 3	stm	1200+	Natl 34-62	1500	17,000
	Bge 6	dsl	1400	Emsco J-1250	1200	17,000
Penrod Drlg Co	15	dsl	2000	GD-2100	2200	25,000
	Bge 46	dsl-elec	2500	Emsco ECB	1250	20,000
Rowan Drlg Co Inc	Bge 20	dsl	1120	Natl 75	1300	12,000
Sea Drlg Corp	*5	dsl	2500	Unit Rig	2500	18,000
Southeastern Drlg Co	Bge 20	—	1600	"Oilwell" 96	2200	16,000
C B Webster Drlg Co	8	stm	1600	Natl FE-23-10½	1200+	15,000
	Bge 9	dsl	1850	Emsco J-1400	2200	17,000
Wheless Drlg Co	5	dsl	2150	Emsco J-1400	1575	18,000
	Bge 6	gas-btne	1000	Wisn Titan	1200	12,000
	Bge 8	dsl	1700	Natl 130	1900	18,000
Fred Wilson Drlg Co	8	gas	1600	Natl 110	1200	16,000
Timbalier Parish						
Salt Dome Prod Co	15	dsl	1500	Natl 110	1500	16,000
Union Parish						
Pyburn Drlg Co	2	gas	315	Wisn	800	9,000
Vermilion Parish						
Circle Drlg Co Inc	8	gas-btne	1200	M-CSCO U-20	1500	13,000
Clegg & Hunt	3	dsl	—	Wisn Titan 56	800	11,500
Columbia Drlg Co	Bge* 1	dsl	800	"Oilwell" 76	750	12,000
Dillard-Waltermire Inc	6	stm	1200	Natl 34-10-FE	1500	16,000
Dixie Drlg Co Inc	4	dsl	1500	Beth 1013	1500	16,000
Falcon Seaboard Drlg Co	11	stm	600	BIW Dreadnt	600	17,000
Gracey-Hellums Corp	Bge 5	dsl	1775	Emsco A-1500	1900	20,000
Nicklos Drlg Co	10	stm	—	Natl	—	17,000
Penrod Drlg Co	11	dsl	2200	Brwstr N-95	1400	15,500
	14	dsl	2200	Brwstr N-12-A	1800	20,000
C B Webster Drlg Co	4	stm	1200	Natl FE-34-10	1200+	15,000
	7	stm	1600	Emsco ECA-10½	1200+	15,000
Fred Wilson Drlg Co	12	gas	1400	Natl 110	1200	16,000
Webster Parish						
Wheless Drlg Co	3	gas-btne	575	Emsco GB-350	450	7,500
Woolf & Magee Inc	1	stm	1000	Natl 34-10-FE	1200	15,000
Winn Parish						
Woolf & Magee Inc	12	gas-btne	275	Beth S-45	275	10,000/2⅛"
MARYLAND						
Garrett County						
Delta Drlg Co	33	gas-btne	624	Natl 50-A	450	7,000
MICHIGAN						
Allegan County						
Calvert Drlg Inc	8	dsl	260	Ideco H-30	190	4,500
Hillsdale County						
Hack Drlg Co	2	btne	—	Crdwll S	161	4,500
	3	btne	—	M-CSCO U-15	412	8,500
Jackson County						
Midwestern Drillers Inc	3	dsl	370	M-CSCO U-15	750	8,500
Sabre Drlg Co	1	dsl	330	M-CSCO U-34	300	5,500/4"
La Peer County						
Calvert Drlg Inc	11	dsl	260	Natl T-32	190	5,000
St. Clair County						
Calvert Drlg Inc	21	dsl	350	Ideco H-35	260	6,500/4"
MISSISSIPPI						
Adams County						
Woolf & Magee Inc	10	gas-btne	275	Beth Breeze	275	10,000/2⅛"
Amite County						
Dixilyn Drlg Corp	1	gas	1050	Natl 75	1050	12,000/3½"
	5	gas	950	Natl 100	950	14,000

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Fortenbery Drlg Co	7	dsl	1000	Ideco M-1000	700	12,000
Justiss-Mears Oil Co Inc	1	dsl	700	Emsco GB-800	1120	13,000
	7	dsl	600	Emsco J-750	900	11,500
	9	gas	350	Emsco GA-500	600	9,500
Jasper County						
Cook Drlg Co	19	gas	1125	Wisn Titan	1125	12,500
Jefferson County						
Fortenbery Drlg Co	1	dsl	300	Ideco H-40	300	8,000
Zach Brooks Drlg Co	8	gas	2600	Brwstr N-12	2600	18,000
Jefferson Davis County						
Cook Drlg Co	16	gas	1125	Wisn Titan	1125	12,500
Dixilyn Drlg Corp	6	dsl	2490	Natl 130	2490	16,000
Reading & Bates Inc	4	dsl	2000	Natl 110	2000	16,000
Jones County						
Zach Brooks Drlg Co	3	dsl	900	Brwstr N-7	900	8,500
	4	gas	1350	Brwstr N-75	1350	12,000
Rimrock Tidelands Inc	12	gas-btne	1000	Natl 75	1215	12,000
Cook Drlg Co	20	gas	1125	Wisn Titan	1125	12,500
	23	gas	1300	Wisn Super Titan	1300	15,000
Rimrock Tidelands Inc	20	dsl	675	Brwstr N-55	900	10,000
Woolf & Magee Inc	8	gas-btne	1300	Beth Tornado	1300	15,000
Lincoln County						
Rimrock Tidelands Inc	19	dsl	1410	Beth MC-950	1200	18,000
Marion County						
Empire Drlg Co	7	gas	650	Wisn Titan	1050	15,000
Rimrock Tidelands Inc	21	dsl	500	Emsco GB-500	600	10,000
Pearl River County						
Justiss-Mears Oil Co Inc	11	dsl	825	Emsco GB-800	1100	13,000
Perry County						
Big Chief Drlg Co	2	gas	1875	Natl 125	1815	16,000
Pike County						
Empire Drlg Co	*3	gas	550	Brwstr N-75	1050	12,000
FWA Drlg Co Inc	5	—	—	—	—	12,000
Reading & Bates Inc	1	gas-btne	1500	Natl 100	1500	14,000
	2	gas-btne	1000	Natl 75	1000	12,000
	3	gas-btne	1000	Natl 75	1000	12,000
Rimrock Tidelands Inc	8	dsl	1000	Brwstr N-75	900	11,000
Sunnyland Contr Co Inc	14	dsl	1800	Beth Tornado	1200	16,000
Rankin County						
Penrod Drlg Co	33	dsl	1500	Brwstr N-12-A	1725	18,000
Simpson County						
Rowan Drlg Co Inc	8	gas-btne	1920	Natl 125	1920	18,000
Smith County						
Arrow Drlg Co	22	dsl	1200	Emsco 1000	—	14,000
Rimrock Tidelands Inc	10	gas-btne	1400	Natl 110	1900	15,000
	11	gas-btne	1325	M-CSCO U-20	1900	20,000
	14	dsl	2000	Emsco A-1500	2000	20,000
Walthall County						
Zach Brooks Drlg Co	9	gas-btne	1350	Brwstr N-95	1350	14,000
Cook Drlg Co	18	gas	750	Wisn Atlas	750	11,500
	22	gas	375	Wisn Spr Mogul	450	10,000
Arrow Drlg Co	24	gas	1200	Emsco 1250	—	14,000
Wayne County						
Sunnyland Contr Co Inc	12	dsl	1120	Ideco H-525SC	1000	10,000
Wilkinson County						
Justiss-Mears Oil Co Inc	10	dsl	280	Emsco GC-250	300	6,000
Yazoo County						
Big Chief Drlg Co	34	dsl-elec	2560	Emsco EDA-460	1600	18,000
MISSOURI						
Holt County						
Nemaha Oil Co	1	dsl	370	Frnks SAL-3000	370	4,500/3½"
MONTANA						
Dawson County						
Helmerich & Payne Inc	8	gas	600	Natl 55	800	9,000
	29	gas	950	Natl 75-CA	1100	11,000
Penrod Drlg Co	19	dsl	825	Brwstr N-7	700	10,000
Roden & McRae Drlg Corp	4	dsl	900	Emsco GB-800	900	12,500
Fallon County						
Zach Brooks Drlg Co	6	dsl	1300	Brwstr N-75	1300	12,500
Glacier County						
Great Northern Drlg Co Inc	2	dsl	300	Crdwll	300	6,000
	3	dsl	600	M-CSCO U-15	600	9,000
Mountain States Drlg Co Inc	9	gas-dsl	1400	Natl 125	—	15,000
Hill County						
Great Northern Drlg Co	6	gas	450	Crdwll D-53	450	8,000

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Tower Building

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P. O. Box 1225, O.C.S.

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Judith Basin County						
Great Northern Drlg Co	5	dsl	450	Crdwll D	450	7,500
Musselshell County						
Fitzpatrick Drlg Co Inc	7	dsl	350	Ideco HB-30-SC	350	5,000
Great Northern Drlg Co	7	gas	350	Crdwll S	225	5,000
Hose-Austin Drlg Corp	1	dsl	350	Emsco GB-250T	450	6,000
	4	gas	500	Emsco GB-350	588	7,500
Oien Oil Corp	3	dsl	500	Natl T-20	280	5,000
Powder River County						
Hose-Austin Drlg Corp	2	dsl	300	Natl T-32	320	5,500
Richland County						
Rutledge Drlg Co	*3	gas-btne	900	Beth 450	850	12,500
Roosevelt County						
Helmerich & Payne Inc	33	gas	850	"Oilwell" 76	1100	11,000
Rosebud County						
Fitzpatrick Drlg Co Inc	2	dsl	500	M-CSCO U-22	500	6,500
Great Northern Drlg Co Inc	1	dsl	300	Brwstr N-4	300	6,000
Stillwater County						
Falcon Seaboard Drlg Co	9	gas	480	Unit U-15	480	8,500
Toole County						
Aikins Drlg Co	3	—	—	Bucyrus 48L	—	9,000
	2	gas-btne	—	Bucyrus 36L	—	5,000
Oien Oil Corp	4	dsl	200	Beth S-50	200	3,000
Wheatland County						
Hose-Austin Drlg Corp	3	gas	450	M-CSCO U-15	550	7,000
NEBRASKA						
Banner County						
Allison Drlg Co	1	gas	450	T-32	450	7,000
Garvey Drlg Co	16	dsl	300	Wisn Rdair	450	7,000/3½"
Cheyenne County						
Inland Drlg Co	1	dsl	425	U-34	425	3,500
Jet Drlg Co Inc	1	dsl	300	Emsco G-500	500	6,500
Devell County						
Sterling Drlg Co	*7	gas	586	Unit U-15	586	7,500
Hitchcock County						
Claude Wentworth Drlg Co Inc	*3	gas-dsl	240	Crdwll "S"	175	5,000
Sterling Drlg Co	*6	dsl	440	Unit U-15	440	6,500
Kimball County						
Ashby Drlg Co Ltd	2	dsl	300	Natl T-20	300	8,000/3½"
Exeter Drlg Co	4	dsl	400	Natl T-32	300	6,000
Garvey Drlg Co	18	dsl	300	Wisn Rdair	450	7,000/3½"
Inland Drlg Co	2	gas	400	Emsco G-36	400	6,000
Love-Miller Drlg Co Inc	1	dsl	450	Wisn Gnt	520	7,000
Merrill County						
Kimbark Expl Co	3	gas	300	Unit U-35	350	5,500
Sterling Drlg Co	*5	gas	586	Emsco PG-350	586	7,000
Red Willow County						
K & E Drlg Inc	*1	dsl	225	"Oilwell" 52-T	300	5,000
	*2	dsl	225	Natl T-20	300	5,000
Richardson County						
Kirby Oil Ind Inc	—	dsl	300	M-CSCO U-34	275	4,500
NEVADA						
Churchill County						
Barry Well Drlg	1	gas-dsl	200	Custom Built	150	2,500
Nye County						
Terminal Drlg & Prod Co	*5	dsl	490	Ideco H-40-D	400	5,000
	*8	dsl	480	Wisn Mogul	350	5,000
	*7	dsl	330	Howard Turner M-1000	120	2,500
	*17	dsl	480	Wisn Mogul	350	5,000
NEW MEXICO						
Chaves County						
Lloyd R French Co	1	gas-btne	765	Natl 50	600	9,000
Moran Oil Prod & Drlg Corp	1	gas	—	M-CSCO U-15	800	8,500
Robinson Bros Drlg Co	2	gas	800	Brwstr N-75	800	10,000
Eddy County						
Bickerstaff & Tibbets Drlg Co	*5	gas	—	Frnks	320	5,000
Delta Drlg Co	3	gas-btne	900	Natl 100	800	12,000
Hissom Drlg Co	*3	gas-btne	—	Emsco 500	600	8,500
Helmerich & Payne Inc	41	gas	1200	Natl 110	1500	15,000
Lee Drlg Co	2	gas-gaso	1050	"Oilwell" 76	—	13,000
	3	gas-gaso	700	Natl 75	—	10,000
	4	gas-gaso	700	Natl 50	700	8,000
	5	gas-gaso	700	Natl 50	700	8,000
	6	gas-gaso	440	Beth S-55	—	6,000
	7	gas-gaso	700	Natl 50	—	8,000
Davey O'Brien Drlg Co Inc	4	gas-btne	280	Wisn Spr	145	3,000
Parker Drlg Co	5	gas	—	Natl 50	700	9,000
Rowan Drlg Co Inc	7	gas-btne	1260	Natl 100	1680	14,000
Tri-Service Drlg Co	6	gas	1350	"Oilwell" 96	1350	16,000
Walters Drlg Co Inc (Dallas)	7	gas	175	Mayhew 1000	175	900/2⅛"
Lea County						
Arrow Drlg Co	27	gas	450	Emsco 500	450	7,500
Delta Drlg Co	4	gas-btne	800	Natl 100	800	12,000
	9	gas-btne	936	Natl 100	800	12,000
Dillard-Waltermire Inc	9	gas	800	Natl 100	1200	13,500
Dual Drlg Co	*6	gas	350	Emsco GA-250	400	5,500
Durham Drlg Co Inc	4	gas	1300	Ideco 7-11	1300	16,000
FWA Drlg Co Inc	3	—	—	—	—	10,000
	12	—	—	—	—	7,000
Helmerich & Payne Inc	32	gas-elec	1100	"Oilwell" 96	1100	14,000
Johnson-Gadbois Drlg Co	*1	LPG	600	Unit U-15	600	8,500
Carl B King Drlg Co of Tex	1	gas-btne	1000	Natl 100	1000	13,500
	20	gas-btne	2100	"Oilwell" 96-16	2100	20,000
King-Phillips Inc	3	dsl	622	Ideco H-40-D	—	5,500/4"
Lee Drlg Co	1	gas-gaso	1050	Natl 100	700	13,000
Lowe Drlg Co	5	gas	750	Natl 75	750	10,000
	4	gas	750	Natl 75	750	10,000
	6	gas	1000	Natl 100	1000	12,500
	8	gas	1500	Natl 80	1500	15,000
	9	gas	2000	Natl 125	2000	17,000
Man Drlg Co	*4	gas	450	Wisn Mogul	450	6,500
Moran Oil Prod & Drlg Corp	3	gas	950	M-CSCO U-15	800	8,500
	4	gas	—	M-CSCO U-34	300	5,000
Dale Mount Drlg Co	112	gas	1200	Emsco 750	1200	12,000
R Olsen	4	gas	1101	Wisn Titan	1101	12,500
Pico Drlg Co	3	gas-btne	610	M-CSCO U-15	470	8,500
Robinson Bros Drlg Co	1	gas	800	Brwstr N-75	800	10,000
Warton Drlg Co	5	gas	325	Natl 50	360	6,000
Rio Arriba County						
Moran Bros Inc	8	gas	1100	"Oilwell" 66	1000	12,000
Nichols Drlg Co	*3	gas	—	—	—	8,500
Rutledge Drlg Co	*4	gas-btne	475	Beth C-50	425	8,000
	*7	gas-btne	356	M-CSCO U-15	555	8,000
Star Drlg Inc	*1	btne	225	Hydrill	150	3,000
Warren-Bradshaw Drlg Co	*20	gas-btne	—	Unit U-15	750	8,500
Roosevelt County						
Brantly Drlg Co Inc	7	gas	975	Beth 450	1125	12,500
Lloyd R French Co	4	gas-btne	1200	Natl 75	900	12,500
San Juan County						
Brannon & Murray Drlg Co	1	gas-LPG	650	Brwstr N-55	550	8,500
	2	gas-LPG	550	Emsco GA-350	550	6,500
	3	gas-LPG	350	Brwstr N-4	250	5,000
	4	dsl	300	Brwstr N-4	300	5,500
	5	dsl	300	Brwstr N-4	300	5,000
Exeter Drlg Co	3	btne	630	Natl 50-A	630	8,500
Foree Drlg Co	2	gas-btne	300	M-CSCO U-15	600	7,500
	3	gas-btne	325	M-CSCO U-15	600	7,500
Lohmann-Johnson Drlg Co Inc	11	gas	325	Natl 50	600	6,000
Man Drlg Co	*3	gas	650	Wisn Gnt	650	6,500
Moran Bros Inc	3	gas	550	Emsco GB-350-52	550	8,000
	9	gas	700	"Oilwell" 66	750	9,500
Nichols Drlg Co	*10	gas	—	—	—	8,000
Rutledge Drlg Co	*5	gas-btne	692	Natl 50	500	8,000
Star Drlg Inc	*2	dsl	225	Failing 90	250	5,000
Warren-Bradshaw Drlg Co	*22	gas-btne	—	Unit U-15	750	8,500
NORTH DAKOTA						
Rowan Drlg Co Inc	27	dsl	1350	Natl 125	1650	15,000
Billings County						
Penrod Drlg Co	31	dsl	1025	Brwstr N-75	830	11,000
Rowan Drlg Co Inc	23	gas-btne	1140	Natl 75	1503	11,000
Bottineau County						
Calvert Drlg Inc	22	gas-btne	320	Ideco H-35	330	5,500
	24	gas-btne	600	M-CSCO U-15	600	9,000
Burke County						
Calvert Drlg Inc	25	gas-btne	1050	Beth 810	1100	12,500
	30	dsl	1000	Brwstr N-75	1000	10,000
Lohmann-Johnson Drlg Co Inc	1	dsl	300	Natl 50	480	5,500
McKenzie County						
Calvert Drlg Inc	26	gas-btne	1380	Natl 80-B	1380	14,000
Helmerich & Payne Inc	15	dsl	975	"Oilwell" 76	1000	11,000
Gabe McCall Drlg Co	3	gas	1200	Natl N-80	1200	12,000
Roden & McRae Drlg Corp	3	dsl	900	Emsco GB-800	900	12,500
Rowan Drlg Co Inc	15	gas-btne	1140	Natl 75	1503	11,000
Rutledge Drlg Co	*1	gas-btne	1100	Beth 810	1257	15,000
Sterling Drlg Co	3	dsl	1100	Emsco GB-800	1100	12,000
Mountrail County						
Penrod Drlg Co	5	dsl	1250	Emsco A-1100	1575	15,000
Pierce County						
Exploration Drlg Co	*9	gas	310	Beth S-50	225	5,500
Williams County						
Rutledge Drlg Co	*6	gas-btne	362	Emsco 350	425	8,000

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
OHIO						
Ashtabula County						
Glenn Gillespie & Sons Inc	*2	gas-dsl	375	Wisn Mogul	275	6,500
Coshocton County						
Walter W Willis	5	dsl	—	Beth S-45-E	—	4,500
Cuyahoga County						
A & P Drlg Co Inc	*2	gas-btne	595	Emsco G-500	275	9,500
Oakwood County						
Bernhardt Drlg Co	1	dsl	300	Failing 2500	300	3,500/2¼"
Portage County						
Glenn Gillespie & Sons Inc	*8	LPG	—	Cpr Skytop 66	200	—
Stark County						
Glenn Gillespie & Sons Inc	*7	dsl	—	Frnks 658 TRD	225	3,000
Al Johnson Drlg Co	2	btne	325	Mayhew	200	3,500
Trumbull County						
Glenn Gillespie & Sons Inc	*3	dsl	275	Wisn Mogul	275	6,500
Wayne County						
Walter W Willis	2	dsl	278	Natl T-12	237	4,500
OKLAHOMA						
Alfalfa County						
Davon Drlg Co	1	gas-LPG	250	Brwstr N-4	320	6,000/3½"
Beaver County						
D & M Drlg Co Inc	3	dsl	600	M-CSCO U-15	600	8,000
Falcon Seaboard Drlg Co	37	gas	600	Unit U-15	600	8,500
Foree Drlg Co	4	gas-btne	325	Emsco GA-500	500	7,500
Jack Grace Drlg Co	5	gas-btne	500	Wisn Atlas	700	10,000
Helmerich & Payne Inc	36	gas	500	Emsco GB-500S2	700	9,000
Lynn Drlg Co	1	gas-btne	300	Natl 50	600	8,000
Midwestern Drillers Inc	7	dsl	370	M-CSCO U-15	750	8,500
	8	dsl	370	M-CSCO U-15	750	8,500
Rheay & Reynolds Drlg Co	4	gas	350	Natl 50	1200	7,000
R W Rine Drlg Co	1	dsl	520	Brwstr N-55	600	8,000
Service Drlg Co	12	gas	700	Wisn Super	700	11,000
	15	gas	400	Wisn Gnt	400	6,000
Unit Drlg Co	*2	gas	900	Unit U-15	900	8,500
Wagner & Wyant Drlg Co Inc	1	dsl	300	M-CSCO U-15	675	8,000
	2	dsl	500	M-CSCO U-15	675	9,000
Earl F Wakefield	2	dsl	640	Wisn Gnt Rdair	640	8,500
Tommy Ward Drlg Co	*2	gas	—	Brwstr N-45	—	—
Warren-Bradshaw Drlg Co	*10	gas-btne	—	Unit U-15	750	8,500
	*54	gas-btne	—	Unit U-15	750	8,500
Blaine County						
Calvert Drlg Inc	27	gas	1250	Wisn Spr	1250	12,500
T T Eason Co Div Eason Oil Co	14	gas	750	Emsco GB-500	940	10,000
Caddo County						
Jet Drlg Co Inc	6	gas-btne	1400	Brwstr N-95	1200	15,000
Parker Drlg Co	57	gas	—	Natl FE 34x10½	1800	18,000
Reed Drlg Co Inc	1	dsl	420	M-CSCO U-34	235	6,000
Canadian County						
Parker Drlg Co	47	gas	—	Natl 100	1400	14,000
Carter County						
Big X Drlg Co Inc	1	gas-btne	750	Beth MC-450	750	10,000
Goff-Leeper Drlg Co	5	gas	850	Ideco H 7-11	850	13,000
Kingery Drlg Co Inc	3	dsl	210	Wisn	350	4,500
	10	btne-gas	300	Wisn	375	4,500
Kirkpatrick Oil Co	1	gas	300	Beth S-60	336	7,500
Nichols Drlg Co	4	—	7000	Wisn	—	7,000
Parker Drlg Co	30	gas	—	Natl 50	700	9,000
	41	gas	—	Natl 100	1400	14,000
Sherin Drlg Co	3	gas-gaso	500	M-CSCO U-15	600	8,000
	4	gas-gaso	1000	Natl 100	1050	12,000
	5	gas-gaso	750	Natl 58	750	9,000
Cimarron County						
Garvey Drlg Co	20	dsl	300	Wisn Mogul 42	450	7,000
Service Drlg Co	*8	gas	320	U-34 Rig	320	6,700
Cleveland County						
Garr-Woolley Co	1	gas-btne	278	Emsco 300	378	6,500
Garvey Drlg Co	21	dsl	500	M-CSCO U-15	640	8,500
Falcon Seaboard Drlg Co	8	gas	900	Beth MC-450	900	10,000
	50	dsl	1065	Natl 75	1065	15,000
Nichols Drlg Co	*8	gas	—	—	—	9,000
Chester H Westfall Drlg Co	2	gas-gas	625	M-CSCO U-15	700	10,400
Coal County						
Warren-Bradshaw Drlg Co	*46	gas-btne	—	Beth S-60	575	8,000
Comanche County						
Bolin Oil Co & D H Bolin	9	LPG or NG	225	Wisn Spr	175	3,500
Bryant-Hayward Drlg Co	4	gas	900	Brwstr N-75	900	12,000
Creek County						
Bodard Drlg Co	*1	gas	225	Unit U-34	185	4,500
Mesker Drlg Co	2	gas	185	Joy 300	160	2,500
Reed Drlg Co Inc	3	gas-gaso	180	M-CSCO U-34	180	3,200

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Custer County						
Parker Drlg Co	61	gas-elec	—	Natl 23 x 10½	2000	20,000
Viersen & Cochran	11	gas	1525	Natl 110	1530	18,500
Dewey County						
Falcon Seaboard Drlg Co	21	gas	600	Unit U-15	600	8,500
Helmerich & Payne Inc	24	gas	950	Natl 80	1100	11,000
	38	gas	950	Natl 80	1100	11,000
Warren-Bradshaw Drlg Co	*58	gas-btne	—	Beth MC-450	700	10,000
Ellis County						
Arrow Drlg Co	11	dsl	595	Emsco 500	—	9,000
Lynn Drlg Co	5	gas-btne	725	Natl 75	900	10,500
J S Montgomery	3	gas	1100	Natl 80	1100	12,000
Viersen & Cochran	9	gas	1300	Emsco J-1250	1590	18,000
Garfield County						
Reed Drlg Co Inc	2	gas-gaso	—	Crdwll D	410	5,500
Garvin County						
Bryant-Hayward Drlg Co	1	gas	675	Natl 50	675	8,500
Crown Drlg Co	*2	gas	750	Unit U-15	750	8,500
Flournoy-Haston Drlg Co Inc	2	gas	300	M-CSCO U-15	650	8,000
Holliman Drlg Co	6	gas	750	Wisn Atlas	950	11,000
Lynn Drlg Co	3	gas-btne	1400	Natl 100	1400	16,000
Nichols Drlg Co	6	gas	—	—	—	15,000
Sherin Drlg Co	1	gas-gaso	500	M-CSCO U-15	600	8,000
Viersen & Cochran	2	gas	850	Natl 55	800	10,500
Grady County						
T T Eason Co Div Eason Oil Co	12	gas	1000	Natl 80-B	1060	12,500
Falcon Seaboard Drlg Co	32	gas	1155	Beth MC-650	1155	14,000
Warren-Bradshaw Drlg Co	*66	gas-btne	—	Wisn Spr Titan	1050	13,000
Dick Wegener Drlg Co	4	gas-dsl	1900	Natl 130	1900	22,000
Grant County						
Lohmann-Johnson Drlg Co Inc	8	dsl	300	Natl 32	550	7,500
Sabre Drlg Co	3	dsl	285	M-CSCO U-36	560	7,500/4½"
Viersen & Cochran	12	gas	325	Natl T-25	225	5,500
	14	gas	325	Natl T-25	225	5,500
Harper County						
An-Son Drlg Co	6	gas	700	Unit U-15	700	9,000
Davon Drlg Co	5	gas-LPG	400	Brwstr N-45	430	7,500
Unit Drlg Co	*3	dsl	750	Natl 50-A	750	8,000
Viersen & Cochran	5	gas	725	Natl 50	800	9,000

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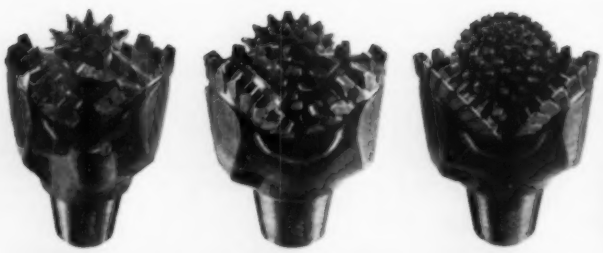

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Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Kay County						
Dave Morgan Drlg Co	—	LPG-gas	350	Natl T-32	320	6,000
Pete Morris Drlg Co	1	dsl-gas	550	Wisn Gnt	550	6,000
Raymond Oil Co Inc	2	dsl	600	Unit U-15	600	8,000
Kingfisher County						
Big Chief Drlg Co	1	gas	450	JS&G Spad Spr	450	6,500
	27	gas	760	JS&G Spad Spr	760	9,000
Bryant-Hayward Drlg Co	2	gas	675	Natl 80	675	8,500
Calvert Drlg Inc	18	gas-btne	—	M-CSCO U-15	585	8,500
	19	dsl	350	M-CSCO U-15	600	8,500
Davon Drlg Co	*3	gas-LPG	500	Brwstr N-7	750	10,000
T T Eason Co Div Eason Oil Co	15	gas	750	Emsco T-250	450	6,900
Garr-Woolley Co	2	dsl	700	Emsco 350	800	8,000
Glenn Gillespie & Sons Inc	*1	gas	370	M-CSCO U-34	300	6,500
	*6	dsl	400	M-CSCO U-34	300	6,500
Hap Drlg Co	*1	gas	1600	Wisn Spr Atlas	1200	12,000
R W Rine Drlg Co	3	gas-btne	520	Brwstr 55	600	8,000
	6	dsl	520	Brwstr N-75	750	12,000
Service Drlg Co	16	gas	1600	Wisn Spr Titan	1600	18,000
Sherin Drlg Co	2	gas-gaso	800	M-CSCO U-15	800	9,000
Slats Honeymoon Drlg Co	1	gas-btne	400	Natl 50-A	600	10,000
	2	elec-dsl	600	U-36-A	600	9,000
Latimer County						
Big Chief Drlg Co	5	gas	1545	Emsco 1250	1545	15,000
Viersen & Cochran	7	gas	1070	M-CSCO U-712-A	1200	15,000
Lincoln County						
Dudley & Heath Drlg Co	7	dsl	265	Brwstr N-4	320	5,500
Lincoln Drlg Co	1	gas	250	Brwstr N-3	185	4,500
Patco Drlg Contr Inc	*1	dsl	325	Unit U-34	300	5,300
Logan County						
Dudley & Heath Drlg Co	6	dsl	265	Crdwll S	320	5,500
Love-Miller Drlg Co Inc	2	dsl	450	Brwstr N-7	520	8,500
Love County						
Falcon Seaboard Drlg Co	24	gas	1350	Beth MC-950	1350	16,000
	42	gas	1350	Beth MC-950	1350	16,000
Major County						
Arrow Drlg Co	20	gas	460	Emsco 350	—	7,000
Big X Drlg Co Inc	2	gas-btne	750	Natl 55	750	10,000
Nichols Drlg Co	9	gas	—	—	—	10,000
Patco Drlg	2	dsl	350	Unit U-15	600	8,000
Sterling Drlg Co	*2	gas-btne	675	Unit U-15	675	7,500
Viersen & Cochran	1	gas	675	Natl 50	450	8,000
McClain County						
An-Son Drlg Co	7	gas	740	Wisn Atlas	830	10,500
Crown Drlg Co	*1	gas	720	Unit U-15	720	8,500
Falcon Seaboard Drlg Co	28	gas	1050	Beth MC-650	1050	14,000
	35	gas	600	Brwstr N-7	600	8,500
	36	gas	1050	Natl 100	1050	12,000
Flournoy-Haston Drlg Co Inc	3	gas	600	Wisn Spec	800	10,000
	4	gas	700	Natl 100	1000	12,000
Goff-Leeper Drlg Co	1	gas	800	Brwstr N-75	800	12,000
	3	gas	450	M-CSCO U-15	450	8,000
	4	gas	850	Wisn Gnt	850	12,500
Holliman Drlg Co	2	gas	350	M-CSCO U-15	550	7,500
Kerr-McGee Oil Industries Inc	16	gas	790	Natl 100	1248	12,500
Nichols Drlg Co	*5	gas	—	—	—	14,000
	11	gas	—	—	8000	8,000
Parker Drlg Co	32	gas	—	Natl 50	700	9,000
	34	gas	—	Natl 75	800	10,000
	37	gas	—	Natl 100	1400	14,000
	55	gas-elec	—	Emsco 750	700	10,000
Service Drlg Co	14	gas	1000	Wisn Titan	1050	15,000
Viersen & Cochran	3	gas	950	Natl 75-CA	800	10,500
	4	gas	950	Natl 75	600	10,500
	8	gas	1250	Emsco J-1000	1200	14,000
Warren-Bradshaw Drlg Co	*68	gas-btne	—	Beth MC-450	700	10,000
Chester H Westfall Drlg Co	1	gas-gaso	625	M-CSCO U-15	700	10,400
McIntosh County						
Goff-Leeper Drlg Co	2	gas	225	Brwstr N-4	350	6,000
Reed Drlg Co Inc	4	gas-gaso	300	M-CSCO U-34	290	5,000
McMullen County						
Parker Drlg Co	52	gas	—	"Oilwell" 76	1400	12,500
Murray County						
Flournoy-Haston Drlg Co Inc	5	gas	700	Natl 100	1000	12,000
Noble County						
Indian Drlg Co	2	dsl	220	Ideco H-35-S	350	5,000
Okfuskee County						
Melco Drlg Co Inc	2	btne	265	Brewstr N-35	185	5,000
Sabre Drlg Co	2	gas	290	T-20	240	5,500/4"
Seran & Howard Drlg Co	1	gas	225	Beth	200	5,000
Shaw-Hughes Drlg Co	3	btne-gas	270	Natl T-20	250	5,000
Unit Drlg Co	*1	gas	290	Unit U-34	226	5,500

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Oklahoma County						
Frizzell Drlg Co	1	gas-gaso	—	Wisn	600	7,500
Okmulgee County						
Wade Drlg Co Inc	3	dsl	325	Crdwll L	225	4,500
Osage County						
Falcon Seaboard Drlg Co	19	gas	194	Unit U-35	240	5,000
Indian Drlg Co	1	btne	220	Ideco H-25	250	4,000
Service Drlg Co	*11	gas	160	AH-Trailer	140	3,000
Shaw-Hughes Drlg Co	2	btne-gas	270	Natl T-20	250	4,500
Pawnee County						
Mike Marrs	*5	gas	225	Wisn	200	4,000
Wade Drlg Co Inc	1	dsl	225	Crdwll L	185	3,500
Payne County						
Davon Drlg Co	4	gas-LPG	200	Brwstr N-2	320	6,500/2⅞"
Sabre Drlg Co	4	gas-LPG	225	Brwstr N-3	180	3,500/4"
Pontotoc County						
Don Clawson	1	gas-btne	340	Brwstr N-4	185	4,500
Pottawatomie County						
A & P Drlg Co Inc	*1	gas-btne	595	Emsco G-450	225	8,500
Bodard Drlg Co	5	gas	450	U-34	185	6,000
Lincoln Drlg Co	2	gas	325	Emsco 250	370	6,000
Viersen & Cochran	13	gas	325	Natl T-16	175	5,200
Seminole County						
M Houston Drlg Co	*2	gas	225	Unit U-34	185	5,500
Melco Drlg Co Inc	1	btne	265	Brwstr N-35	185	5,000
Stephens County						
Big Chief Drlg Co	30	gas	1545	Ideco 1050	1515	15,000
	35	gas	2610	Natl 110	2610	16,000
Falcon Seaboard Drlg Co	51	gas	1600	Natl 125	1600	25,000
Helmerich & Payne Inc	44	gas	1200	"Oilwell" 96	1500	15,000
	47	gas-btne	2000	"Oilwell" 96-16	2000	20,000
Holliman Drlg Co	1	gas	500	M-CSCO U-15	900	8,500
	4	gas	325	M-CSCO U-15	500	7,500
Nichols Drlg Co	*1	gas		Wilson		7,000
Quad Drlg Co	*1	gas	250	Frnks	3000	5,000
Chester H Westfall Drlg Co	3	gas-gaso	625	M-CSCO U-15	700	10,400
Texas County						
Helm Drlg Co	5	dsl	440	"Oilwell" 52-T	300	6,000
	6	dsl	520	Wisn Gnt	600	8,000
Carl B King Drlg Co of Tex	11	gas-btne	900	Natl 75	900	11,000
Luke Grace Drlg Co	4	dsl	270	Wisn Gnt	270	5,500
Midwestern Drillers Inc	2	dsl	320	M-CSCO U-15	600	7,500
Moran Bros Inc	2	gas	700	Emsco GA-500	750	9,500
Tommy Ward Drlg Co	*3	gas		Brwstr		
R W Rine Drlg Co	4	gas-btne	620	Brwstr N-75	750	10,000
Tulsa County						
Mesker Drlg Co	1	gas	214	Joy 300	170	2,500
Wilcox Drlg Co Inc		dsl	200	Frnks C-H 2000	150	2,000
Union						
M Houston Drlg Co	1	gas	700	Wisn Gnt	700	10,000
Washita County						
Parker Drlg Co	60	gas-elec		Natl 130	2000	20,000
Woods County						
Viersen & Cochran	10	gas	675	Natl 50	450	8,500
Woodward County						
An-Son Drlg Co	2	gas	700	Unit 15	700	9,000
Davon Drlg Co	2	gas-LPG	380	Brwstr N-4	320	6,500
Falcon Seaboard Drlg Co	38	gas	770	Wisn Atlas	770	10,000
Helmerich & Payne Inc	26	gas	500	Emsco GB-500	700	9,000
Parker Drlg Co	56	gas		Natl 50	700	9,000
Earl F Wakefield	6	dsl	960	Wisn Atlas Rdair	960	13,000
OREGON						
Lake County						
Sun Drlg Co	*3	dsl	1300	Natl 110	1950	16,000
PENNSYLVANIA						
Bedford County						
Delta Drlg Co	27	dsl	380	Emsco GA-350	350	6,000
Clearfield County						
Delta Drlg Co	34	gas-btne	800	M-CSCO U-15	600	8,000
Fairman Drlg Co	1	gas-btne	500	Beth M-58	600	10,000
	2	gas-btne	500	"Oilwell" 66	600	9,000
	3	gas-btne	500	Wisn Gnt	600	9,000
S W Jack Drlg Co	1	gas	635	M-CSCO U-15	635	8,500
	3	gas	650	M-CSCO U-15	650	8,500
Clinton County						
Delta Drlg Co	24	dsl	670	Emsco GC-500	500	8,500
Fayette County						
Lohmann-Johnson Oil Co Inc	10	dsl	—	M-CSCO U-15	500	6,000
Indiana County						
S W Jack Drlg Co	2	dsl	800	M-CSCO U-15	800	8,500

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Jefferson County						
Delta Drlg Co	30	dsl	670	Emsco G-500	500	8,500
Somerset County						
Delta Drlg Co	10	dsl	560	M-CSCO U-15	560	7,000
Washington County						
Lohmann-Johnson Oil Co Inc	9	gas	750	"Oilwell" 66	500	10,000
Westmoreland County						
Lohmann-Johnson Oil Co Inc	2	gas	750	"Oilwell" 76	500	10,000
		TEXAS				
Anderson County						
Robert M Bass Drlg Contr	5	gas-LPG	300	Wlsn Gnt	300	5,500
Travis Ward Drlg Co	2	dsl	1550	Wlsn Titan	1100	12,500
Andrews County						
Brantly Drlg Co Inc	8	gas	675	Beth 450	870	11,500
Davidson Drlg Co Inc	*C	btne	660	Emsco GC-500	660	8,500
Dual Drlg Co	*5	gas	700	Emsco 500	700	8,500
Durham Drlg Co Inc	3	gas	1250	Unit U-20	1250	14,000
Frontier Drlg & Prod Co	*6	dsl	350	Brwstr N-4	300	4,000
FWA Drlg Co Inc	9	—	—	—	—	5,000
	11	—	—	—	—	9,000
Helmerich & Payne Inc	43	gas	900	"Oilwell" 76	1100	11,000
Hissom Drlg Co	*12	gas-btne	—	Unit U-34	650	6,500
King-Phillips Inc	4	gas	700	Beth S-45-E	350	6,500
Lowe Drlg Co	1	gas	500	M-CSCO U-15	500	7,500
	10	gas	1800	Natl 125	1800	17,500
Parker Drlg Co	4	gas	—	Natl 100	1400	14,000
	28	gas	—	Natl 50	700	9,000
	51	gas	—	Natl 50	700	9,000
Pico Drlg Co	8	gas-btne	756	Beth M-58	925	10,500
Fred Pool Drlg Co	3	—	—	Unit U-10	—	5,500
Aransas County						
Camden Drlg Co	Bge 2	dsl	600	Natl T-32	300	7,500
Penrod Drlg Co	21	dsl	1850	Brwstr N-85	1200	13,500
Atascosa County						
General Well Drlg Inc	3	gas-btne	425	Beth	183	5,500/3½"
Hunt Drlg Co Inc	4	gas	846	Emsco GB-250	306	7,000
Austin County						
Big "6" Drlg Co	2	gas-btne	700	M-CSCO U-15	700	11,000
Bee County						
Armstrong & Horn Drlg Co	1	dsl	450	Brwstr N-45	—	7,000
Buzzini Drlg Co	9	gas prop	1880	Wlsn Titan	1880	20,000
Harkins & Co	3	gas-gaso	850	M-CSCO U-15	850	10,000
Viking Drlg Co	3	gas-gaso	800	M-CSCO U-15	660	9,000
Borden County						
Rheay & Reynolds Drlg Co	5	gas	350	Natl 75	1200	8,000
Bowie County						
Taylor Expl Co Inc	4	gaso	—	Mayhew	75	1,000
Brazoria County						
C J Foster Drlg Co	*9	gas	800	Houston Port CT-5	500	8,500
Grey Wolf Drlg Co	4	gas-btne	780	Emsco GB-500	890	9,500
Meadows & Walker Drlg Co	4	gas-btne	1455	"Oilwell" 76	1005	12,000
	2	power	1950	Beth 1500	1578	16,000
Calhoun County						
E L Bass Drlg Co	*1	rotary	—	Unit U-15	—	10,000
	*2	rotary	—	Unit U-15	—	10,500
Layton Brown Drlg Co	*2	dsl	810	Brwstr N-7	600	11,000
	3	stm	—	—	—	10,000
	*4	dsl	1890	"Oilwell" 95	1080	16,000
Callahan County						
Wes-Tex Drlg Co	2	btne	220	Brwstr N-4	400	5,500
Carson County						
FWA Drlg Co Inc	14	—	—	—	—	4,500
	18	—	—	—	—	4,500
Service Drlg Co	10	gas	202	Unit U-34	190	4,500
Cass County						
Big Chief Drlg Co	38	gas	900	Natl 75	900	13,000
B G Byars Power Drlg Co	4	gas-btne	1110	Emsco J-750	1110	14,000
M J Delaney Co	27	gas-btne	500	Beth 450	850	11,000
	32	gas-btne	500	Beth 450	750	11,000
Jet Drlg Co Inc	3	dsl	1000	Brwstr N-75	700	11,000
Chambers County						
Big "6" Drlg Co	5	gas-btne	820	Wlsn Gnt	550	10,500
Brewster-Bartle Drlg Co Inc	4	gas	—	"Oilwell" 76	—	11,000
	15	gas	—	Emsco	—	10,000
Steen Drlg Co	3	btne-gas	700	Emsco J-750	1000	11,500
Cochran County						
Brantly Drlg Co Inc	4	gas	375	Beth S-55	480	6,500
	5	gas	375	Emsco 250	250	4,000
Johnson-Gadbois Drlg Co	*2	LPG	450	Wlsn Mogul	450	5,500
Coleman County						
Rhodes Drlg Co	11	gas	240	Emsco 350	360	5,000

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Colorado County						
C J Foster Drlg Co Inc	10	dsl	2150	Natl 125	1350	16,000
Harkins & Co	1	gas-gaso	555	M-CSCO U-15	555	9,500
Meadows & Walker Drlg Co	1	gas-btne	875	"Oilwell" 66	828	10,500
Comanche County						
Low Drlg Co	2	btne	—	Wlsn	145	3,000
Raiborn Drlg Co	2	gas	200	Crdwll RL	185	5,000
Cooke County						
Alan Drlg Co	*3	gas	300	Wlsn Mogul	185	3,500
Berry Drlg Co	1	dsl	350	Wlsn Gnt	500	6,500
MartinDee Drlg Co	1	btne	150	Wlsn	105	1,500
	2	btne	230	Wlsn Gnt	215	5,500
	3	btne	350	Wlsn Gnt	450	6,500
Felderhoff Bros Drlg Co	1	gas	285	Wlsn Mogul	185	4,600
Luke Grace Drlg Co	6	dsl	270	Wlsn Gnt	270	6,500
Roy Guffey Drlg Co	5	gas-btne	550	M-CSCO U-34	260	5,500
Russell & Russell Drlg & Prod Co	*2	—	400	Wlsn Torcair	450	5,000
T & O Drlg Co	1	gas	340	Unit U-34	230	5,000
	2	dsl	200	Wlsn Spr	130	3,000
	3	gas	240	Wlsn Mogul	145	4,500
Trachta Drlg Co	1	dsl	250	Wlsn	185	3,000
Crane County						
Brantly Drlg Co Inc	1	gas	365	Emsco 500	500	9,000
E B Clark Drlg Co	1	gas-btne	750	Emsco G-500	600	7,500
Helmerich & Payne Inc	42	gas	970	Natl 100	1000	13,000
Dale Mount Drlg Co	101	gas	850	Emsco 500	570	9,000
	111	gas	1200	Emsco 1250	1200	14,000
Gene McCutchin Drlg Co	*8	gas	550	Natl 50	550	8,000
Parker Drlg Co	53	gas	—	Natl 75	1000	11,000
Ray Smith Drlg Co Nancy Ann II		gas-LPG	225	Ideco H-25	160	4,500/3½"
Crockett County						
Henry Black Drlg Co	2	gas-gaso-btne	700	Natl 75	750	11,000
Brantly Drlg Co Inc	3	gas	700	Brwstr N-75	750	11,000
Delta Drlg Co	6	gas-btne	800	Emsco J-750	750	9,500
John Grappe Drlg Co	*3	gas	1700	Beth M-58	850	12,000
Dale Mount Drlg Co	115	gas	1200	Emsco 750	1200	12,000
Rowan Drlg Co Inc	22	gas-btne	600	Natl 50	766	7,000
Schoenfeld-Hunter-Kitch Drlg	9	gas-LPG	—	Natl 75	900	11,000
Warton Drlg Co	2	gas	600	Natl 50	700	8,500
Crosby County						
Layton & Newell Drlg Co	2	gas-btne	450	Natl 75	780	12,000
Culberson County						
Coroco Drlg Co	1	gas-gaso	500	Beth 650	650	12,500
Dallam County						
Warren-Bradshaw Drlg Co	*24	gas-btne	—	Unit U-15	750	8,500
Dallas County						
Walters Drlg Co Inc (Dallas)	5	gas-btne	—	Mayhew	100	500
Dawson County						
Coroco Drlg Co	6	gas-gaso	400	"Oilwell" 66	500	9,000
O E Hall Drlg Co	5	gas	700	M-CSCO U-40	1210	12,000
Hissom Drlg Co	*1	gas-btne	—	Emsco 500	675	10,000
Kerr-McGee Oil Industries, Inc	7	gas	885	Natl 75	818	11,500
Dale Mount Drlg Co	114	gas	300	Crdwll	300	5,000
Rowan Drlg Co Inc	25	gas-btne	1260	Natl 100	1680	14,000
Warton Drlg Co	3	gas	1620	Natl 110	1600	14,000
	4	gas	950	Emsco J-750	1000	12,000
De Witt County						
Grey Wolf Drlg Co	2	dsl elec	1250	Emsco ECA	1250	22,000
Harkins & Co	8	gas-btne	1625	N-100	1810	14,500
Penrod Drlg Co	3	dsl	2200	Brwstr N-95	1400	15,500
Dimmit County						
Wagner & Wyant Drlg Co Inc	3	dsl	300	M-CSCO U-34	300	5,000
Duval County						
Continental Marine Expl Co	5	gas-btne	1480	Wlsn Titan	700	12,000
Falco Drlg Co	1	gas	700	Brwstr N-45	450	6,500
Field Drlg Co	1	dsl	1040	Natl 50-A	520	9,500
	5	dsl	1750	Natl 80	1050	14,000
General Well Drlg Inc	7	dsl	650	Crdwll	300	7,500
Ector County						
Big West Drlg Co	17	gas-btne	600	Wlsn Titan	900	13,000
Forest Blackstock Inc	4	gas	700	Emsco GB-350	700	8,000
Davidson Drlg Co Inc	*D	btne	315	Wlsn Mogul	600	7,500
Delta Drlg Co	2	gas-btne	400	Natl 50	450	7,000
Dillard-Waltermire Inc	12	gas	600	Wlsn Gnt	800	8,000
	14	gas	600	Wlsn Gnt	800	8,000
	16	gas	500	Natl 50	700	6,500
Durham Drlg Co Inc	2	gas	648	Unit U-15	648	8,500
Lloyd R French Co	3	gas-btne	650	Natl 50	600	7,500
FWA Drlg Co Inc	4	—	—	—	—	7,000
O E Hall Drlg Co	1	gas	320	M-CSCO U-15	700	8,000
Hissom Drlg Co	*8	gas-btne	—	Emsco A-800	1050	13,000
King-Phillips Inc	1	gas-gaso	695	Natl 50	—	7,500

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Parker Drlg Co	16	gas	—	Natl 100	1400	14,000
	33	gas	—	Natl 75	1000	11,000
	39	gas	—	Natl 100	1400	14,000
Robinson Bros Drlg Co	4	gas	300	Brwstr N-45	450	6,500
Schoenfeld-Hunter-Kitch Drlg Co	1	gas-LPG	—	Beth 650	1000	14,000
	4	gas-LPG	—	Natl 75	800	11,000
	6	gas-LPG	—	Beth 650	1000	14,000
	7	gas-LPG	—	Natl 110	1425	16,000
	10	gas-LPG	300	Beth Twister	300	6,500
Tri-Service Drlg Co	2	gas	675	"Oilwell" 66	675	8,500
Erath County						
Wes-Tex Drlg Co	7	btne	200	Crdwll D	225	3,000
Fayette County						
Hamman Oil & Ref Co	7	dsl	340	Brwstr N-75	600	11,000
Fisher County						
Bolin Oil Co & D H Bolin	3	LPG or NG	350	Wisn Gnt	250	5,000
Sojourner Drlg Corp	4	btne	225	M-CSCO U-34	225	4,500
West Central Drlg Co	12	gaso-btne	675	Wisn Rdair	675	10,000
Foard County						
Meredith Drlg Co	1	gas-btne	225	NK Wauk Wisn Spr	145 Wauk	3,500
Franklin County						
Arrow Drlg Co	17	gas	1260	Emsco 1250	—	14,000
M J Delaney Co	28	gas-btne	500	"Oilwell" 96	1000	14,000
Parker Drlg Co	44	gas	—	Natl 125	1400	15,000
Freestone County						
M J Delaney Co	31	gas-btne	450	Wisn Gnt Rdair	650	9,000
Frio County						
J E Miller	3	dsl	800	Crdwll KM-250	400	7,500/3½"
Ft Bend County						
Grey Wolf Drlg Co	3	stm	4-150	BIW Type 2 stm pumps	3-20"	13,500
Gaines County						
Bickerstaff & Tibbets Drlg Co	*7	gas	—	Emsco G-36	450	5,500
Dual Drlg Co	4	—	600	Beth 810	1100	13,000
FWA Drlg Co Inc	2	—	—	—	—	9,000
	10	—	—	—	—	5,000
O E Hall Drlg Co	3	gas	600	M-CSCO U-15	700	8,000
Moran Oil Prod & Drlg Corp	2	gas	—	Natl 75	750	10,000
Parker Drlg Co	59	gas	—	Natl 75	1000	11,000
Rowan Drlg Co Inc	12	gas-btne	1260	Natl 100	1680	14,000
Ray Smith Drlg Co Sophie Jean		gas-LPG	625	Natl 50	625	8,000
Galveston County						
Brewster-Bartle Drlg Co Inc	12	dsl	—	"Oilwell" 96	1500	16,000
Continental Marine Expl Co	Bge 10	dsl	1245	"Oilwell" 96	1080	18,000
	Bge 12	dsl	2000	Wisn Titan 66	1875	22,800
C J Foster Drlg Co Inc	1	stm	1800	Emsco ECB	1400	15,000
	2	gas	985	Brwstr N-75	750	12,000
	4	gas	1120	Crdwll "O"	750	11,500
	*8	gas	800	Houston Port CT-5	600	9,500
Kilroy Drlg & Prod Co	3	gas	1000	Brwstr 75	1000	12,000
Penrod Drlg Co	20	dsl	1400	Natl 80-B	1400	13,500
Garza County						
Black Drlg Co	1	dsl	275	Frnks	250	4,000/3½"
Dual Drlg Co	3	gas	600	Beth M-58	600	10,000
Hissom Drlg Co	*7	gas-btne	—	Crdwll 405	—	5,000
Robinson Drlg Co (Colo City)	3	gas	250	Beth MC-250	300	5,000
Goliad County						
General Well Drlg Inc	8	btne	400	Brwstr N-4	185	4,500/3½"
Harkins & Co	4	gas-gaso	700	Wisn Gnt	700	9,500
Viking Drlg Co	5	gas	650	M-CSCO U-10	520	8,500
Gray County						
FWA Drlg Co Inc	13	—	—	—	—	4,500
Holt Bros Drlg Co	*2	dsl	270	Ideco H-20	270	4,000
Kerr-McGee Oil Industries Inc	*34	dsl	300	Frnks LTX 5000	300	5,000
Murphy & McKernan	1	dsl	390	M-CSCO U-15	375	7,500
Grayson County						
Falcon Seaboard Drlg Co	15	gas	1155	Unit U-20	1155	14,000
	33	gas	1350	Beth MC-1013	1350	20,000
	40	gas	1540	Beth MC-950	1540	20,000
	41	dsl	1350	Beth MC-950	1350	16,000
FWA Drlg Co Inc	6	—	—	—	—	4,500
	16	—	—	—	—	4,500
Jack Grace Drlg Co	12	gas-btne	700	Wisn Titan	1350	12,000
Nichols Drlg Co	2	gas	—	—	—	14,000
Gregg County						
Carter-Jones Drlg Co	6	gas-btne	—	Wisn Gnt	350	6,800
	7	gas-btne	—	Wisn Gnt	300	6,500
	8	gas-btne	—	Wisn Rdair	500	7,500
	12	gas-btne	—	Wisn Spr Gnt	720	9,000
Halbert Drlg Co	3	gas-btne	710	M-CSCO U-15	710	9,500

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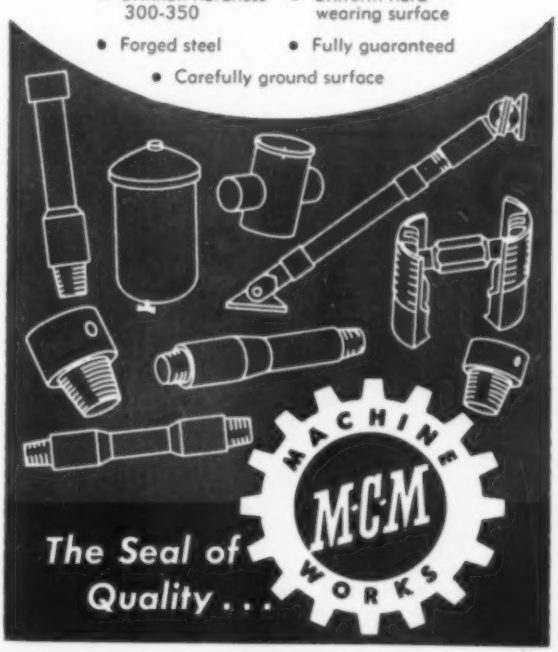
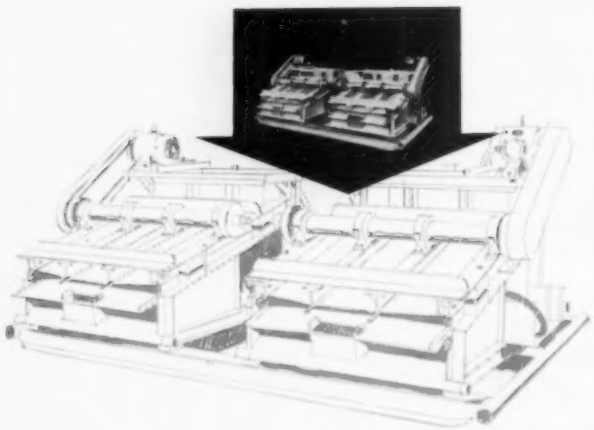


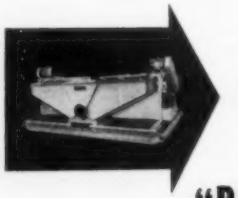
The Seal of Quality . . .

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Hamilton County						
Rheay & Reynolds Drlg Co	6	gas	300	Natl 50	750	7,000
Hansford County						
Dillard-Waltermire Inc	1	gas	600	Wlsn Gnt	—	8,000
Moran Bros Inc	6	gas	900	Wlsn Gnt	750	9,500
Helmerich & Payne Inc	7	gas	500	Emsco GB-500-82	700	9,000
Jack Grace Drlg Co	8	gas-btne	600	Wlsn Gnt	700	8,000
Luke Grace Drlg Co	18	dsl	540	Unit 15	540	9,000
Hardeman County						
E W Moran Drlg Co	2	gas	500	Wlsn Gnt	650	7,500
Sheets & Walton Drlg Co	3	pwr	365	Brwstr N-4	285	5,000
Hardin County						
Houston Oil Well Serv Co	4	gas-btne	—	Ideco M-10,000	855	10,000
Meredith & Co	*1	gas-gaso-btne	800	Emsco G-500	500	9,500
Miller Bros & Bowling	2	gas-btne	800	Emsco G-450	—	8,500
Harris County						
Appell Petroleum Corp	3	gas-gaso	510	Brwstr N-4	225	6,000
Hunt Drlg Co Inc	3	gas	965	Emsco GB-350	480	8,500
	5	gas	1650	Beth MC-650	1200	16,000
Mac Drlg Co	11	stm	800+	Natl 23-9F-ED	1000+	20,000
Lubie Martin Drlg Co	1	power	400	Brwstr N-4	450	6,000
Taylor Expl Co Inc	6	btne	—	Failing	—	1,200
ULB Drlg Co	*2	gas-gaso-btne	370	Unit U-34	220	5,000
Harrison County						
Tex-Mex Drlg Co	6	gas-btne	1200	Wlsn Titan	1200	13,000
Hemphill County						
Parker Drlg Co	54	gas	—	Natl 125	1400	20,000
Service Drlg Co	3	gas	700	Unit U-15	700	8,500
Hendersen County						
B G Byars Power Drlg Co	2	gas-btne	1145	Emsco GA-500	750	10,500
Travis Ward Drlg Co	1	dsl	600	Wlsn Gnt	300	6,500
	3	gas-LPG	2000	Wlsn Spr Titan	1400	16,000
	4	gas-LPG	1000	Wlsn Spr Titan	1200	16,000
Hidalgo County						
Appell Petroleum Corp	2	dsl	685	Frnks SG-101	400	8,500
	4	gas-gaso	630	Crdwll	370	7,000/3½"
Chiles Drlg Co	4	gas	1000	Brwstr N-7	600	10,500
Falco Drlg Co	2	gas	750	Ideco Spr 750	500	9,500
Gilmour Drlg Co	*1	dsl or gas	350	Unit U-15	600	8,500
Monte Cristo Drlg Corp	2	gas-btne	850	Emsco GA-500	700	8,500
	3	gas-btne	950	Natl 55	900	10,000
Penrod Drlg Co	4	dsl	2300	Natl 130	1500	20,000
Stewart & Gouger Drlg Co	3	gas-btne	700	Emsco GB-500	700	9,500
Viking Drlg Co	1	dsl	475	Natl 50	500	8,500
	2	dsl	475	Natl 50-A	500	8,500
Hockley County						
Lowe Drlg Co	7	gas	1250	Natl 100	1250	12,500
Sitton & Norton Drlg Co	*1	gas-btne	380	Wlsn Gnt	380	5,600
Houston County						
Ace Drlg Co	4	gas-btne	500	Emsco G-500	630	9,000
Columbia Drlg Co	6	dsl	1060	Emsco GA-500	660	11,000
Howard County						
John Grappe Drlg Co	*2	gas	1700	Beth M-58	700	12,000
Davey O'Brien Drlg Co Inc	1	gas-btne	700	Emsco GA-500	700	9,000
	2	gas-btne	840	Emsco GA-500	840	9,000
Hunt County						
B G Byars Power Drlg Co	1	gas-btne	1170	Beth MC-450	775	11,000
Maxwell Herring Drlg Corp	2	—	—	—	—	11,000
Hutchinson County						
Arrow Drlg Co	9	gas	560	Emsco 500	—	9,000
E W Moran Drlg Co	3	dsl	500	Wlsn Gnt	650	7,500
WB Omohundro	8	btne	700	Wlsn Rdair	—	8,000
H F Sears	*14	dsl	300	Unit U-34	300	5,000
Service Drlg Co	6	gas	295	Brwstr N-4	230	5,000
	9	dsl	290	Natl T-12	300	4,000
Sojourner Drlg Corp	2	dsl	320	M-CSCO U-15	265	5,000
Spradling Drlg Co	1	gas	325	M-CSCO U-34	290	5,000
	2	gas	225	M-CSCO U-24	180	4,000
Jack County						
H O Grace Drlg Co	3	btne	—	—	—	6,000
Graytex Drlg Co	1	gas	325	Natl T-32	400	6,500
Leatherwood Drlg Co	5	gas	440	Wlsn Gnt Rdair	440	7,000
E W Moran Drlg Co	6	gas	225	Wlsn Mogul	160	4,500
Jackson County						
Chiles Drlg Co	3	gas	500	Ideco H-40-D	460	8,500
Dan L Clark Drlg Co Inc	2	gas-btne	1000	Emsco GC-500	500	7,500
	5	gas-btne	1025	Brwstr N-7	800	10,000
Field Drlg Co	3	dsl	1110	Emsco 500	520	10,000
Frio Drlg Inc	2	dsl	400	M-CSCO U-15	400	6,500
H H Howell	1	dsl	375	Frnks 5000	250	5,000

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Jefferson County						
Clegg & Hunt	4	stm	—	Ideco Big Gnt	—	15,000
	7	dsl	—	Natl 75	880	11,000
	10	gas-btne	—	Natl 50-A	—	10,000
Dillard-Waltermire Inc	2	dsl	1800	Natl 125	2400	16,000
Meredith & Co	3	gas-gaso-btne	1100	"Oilwell" 96	1100	14,000
	4	gas-gaso-btne	1050	Brwstr N-75	860	11,500
Jim Wells County						
Allen & Shumate Inc	5	gas	300	Ideco H-30	280	4,500
General Well Drlg Inc	1	pwr	450	Wlsn Rdair	200	6,000/3½"
Harkins & Co	2	dsl	300	Wlsn Gnt	300	6,500
Jones County						
Rhodes Drlg Co	1	dsl	480	Natl T-20	480	5,500
	10	gas	250	Failing 2500	290	2,500
Sojourner Drlg Corp	5	btne	225	Natl T-8-S	145	3,250
West Central Drlg Co	7	gaso-btne	225	Wlsn Gnt	250	5,000
Karnes County						
Allen & Morris Drlg Co	5	gas-btne	780	OWSCO 76	900	12,000
Buzzini Drlg Co	8	gas-prop	1670	Wlsn Titan	1220	14,000
Viking Drlg Co	4	gas-gaso	980	Ideco M-10,000	750	12,000
Kent County						
Empire Drlg Co	8	gas	500	Unit U-15	675	9,000
Sojourner Drlg Corp	3	dsl	550	M-CSCO U-15	520	7,500
King County						
W B Omohundro	4	btne	450	Wlsn Mogul Trcr	—	6,000
Kinney County						
Dixon Drlg Co	*1	dsl	265	Natl T-20	260	5,000
Kleberg County						
J & C Drlg Co	5	dsl	1143	Wlsn Titan	1143	12,500
Stewart & Gouger Drlg Co	4	gas or btne	1000	Natl 110	1100	16,000
Knox County						
Abb Drlg Co	3	gas	185	Wlsn Spr	145	3,000
Graytex Drlg Co	2	gas	325	Natl T-12	325	4,500
Sojourner Drlg Corp	11	btne	450	Unit U-15	—	—
Lamb County						
Sitton & Norton Drlg Co	*2	gas-btne	680	Natl 75	680	11,000
Lavaca County						
Chiles Drlg Co	5	gas	1700	Brwstr N-95	1500	14,000
Penrod Drlg Co	32	dsl	1600	Brwstr N-12	2100	18,000
Lee County						
Allen & Morris Drlg Co	7	dsl	1240	NSCO 75	1200	12,000
Leon County						
Robert M Bass Drlg Contr	4	gas-LPG	350	Brwstr N-45	350	7,000
Liberty County						
Big "6" Drlg Co	3	gas-btne	500	Crdwll Tlrg	500	7,500
Houston Oil Well Serv Co	2	dsl	—	Wlsn Titan	1000	10,000
Limestone County						
Walters Drlg Co Inc (Dallas)	9	gaso	130	Mayhew 1000	130	800/2½"
	14	gas	—	Mayhew 1000	150	400/2½"
Live Oak County						
Allen & Morris Drlg Co	8	stm	1100	Emsco UB-LS-54	1200	12,000
Boyd & Durst Drlg Contr	2	gas-btne	650	Wlsn Gnt	700	8,500
Chiles Drlg Co	1	gas	600	Emsco 500	600	8,500
Schimmel Drlg Co	1	dsl	350	Wlsn Gnt	600	8,000
Loving County						
Leatherwood Drlg Co	1	dsl	1200	Jr Ideco 7-11	1590	14,000
	2	gas	440	Natl T-32	—	7,000
	3	dsl	500	Natl T-20	—	6,000
	7	gas	650	Natl 50	—	10,000
Lynn County						
Davey O'Brien Drlg Co Inc	5	gas-btne	560	Wlsn Gnt	560	8,000
West Central Drlg Co	8	gaso-btne	900	Wlsn Rdair	675	10,000
Madison County						
Meadows & Walker Drlg Co	3	gas-btne	900	M-CSCO U-15	675	8,500
Marion County						
Tex-Mex Drlg Co	7	gas	—	Emsco GB-350	—	7,500
Martin County						
Coroco Drlg Co	2	gas-gaso	650	"Oilwell" 96	900	15,000
Davidson Drlg Co Inc	*A	gas-btne	1000	Emsco J-1250	1000	14,000
Lloyd R French Co	2	gas-btne	675	M-CSCO U-15	600	7,500
Helmerich & Payne	9	gas	1200	"Oilwell" 96	1100	14,000
Carl B King Drlg Co of Tex	7	gas-btne	1000	Natl 100	1000	13,500
Rowan Drlg Co Inc	28	gas-btne	1300	Natl 125	1530	15,000
Matagorda County						
Columbia Drlg Co	2	NG-btne	1375	Natl 75	675	11,500
Dillard-Waltermire Inc	4	stm	1200	Natl 34-10FE	1500	16,000
Edman Drlg Co	3	dsl	1000	MC U-15	900	10,000
Grey Wolf Drlg Co	1	gas-btne	1170	Emsco GB-880	1050	12,500
Hamman Oil & Ref Co	6	dsl	250	Brwstr N-4	310	6,500
Hunt Drlg Co Inc	7	stm	1200	Emsco ECA	1200	16,000
Mac Drlg Co	7	stm	500	Natl 34-26	5000	10,000
	10	gas-btne	1000	Natl 130	1300	20,000
	12	stm	500	Natl 23-9-FED	1000+	20,000

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Meadows & Walker Drlg Co	5	gas-btne	2062	Beth	1988	16,000
Neal Drlg Co	1	gas	1000	Natl 100	1000	13,500
Steen Drlg Co	1	stm	750	Emsco ECB	—	17,000
Stewart & Gouger Drlg Co	5	dsl	1500	Unit 914-C	1700	18,000
Triton Drlg Co	8	gas	500	Unit U-15	800	10,500
McMullen County						
Allen & Morris Drlg Co	4	gas-btne	590	NSCO 50	450	9,000
Hunt Drlg Co Inc	2	stm	1200	Emsco UBLS-54	1200	12,000
Field Drlg Co	2	dsl	1000	M-CSCO U-15	750	10,000
Parker Drlg Co	58	gas	—	Natl 100	1400	14,000
Menard County						
Dixon Drlg Co	5	gas	400	Unit U-15	600	7,000
Midland County						
Henry Black Drlg Co	4	gas-btne	750	Natl 75-CB	900	11,500
	6	gas-btne	550	Unit U-15	700	8,500
	7	gas-btne	1050	Natl 100	1350	15,000
Dixilyn Drlg Corp	3	gas	950	Natl 100	950	14,000
Fryer & Hanson Drlg Co	4	gas-btne	1150	"Oilwell" 76	1200	12,000
	10	gas-btne	225	M-CSCO U-34	275	4,500
	11	gas-btne	1200	Beth M-58	1200	12,000
Lowe Drlg Co	2	gas	750	Wisn	750	10,000
Davey O'Brien Drlg Co Inc	3	gas-btne	700	Emsco GB-500	700	9,000
Rowan Drlg Co Inc	9	gas-btne	900	Natl 75	1110	11,000
Mitchell County						
Robinson Drlg Co (Colo City)	*1	gas	400	M-CSCO U-15	525	9,000
	*2	gas	450	M-CSCO U-15	600	9,000
Montgomery County						
Mobile Drlg & Well Serv Co Inc	1	gas-btne	490	Ideco HD-35	450	7,000/3½"
Navarro County						
Maxwell Herring Drlg Corp	8					5,000
Newton County						
Edman Drlg Co	2	gas	1000	Brwstr N-75	900	12,000
Mac Drlg Co	5	gas-gaso-btne	275	Beth S-45	450	7,500
Steen Drlg Co	4	gas-btne	1350	Ideco 1050	1350	16,000
Nolan County						
Roy Guffey Drlg Co	3	gas-btne	550	M-CSCO U-34	260	5,500
Wes-Tex Drlg Co	5	btne	550	Natl 50	550	7,500
Nueces County						
Allen & Morris Drlg Co	2	stm	1100	BIW 12	1200	14,000
Frio Drlg Inc	3	gas-btne	800	Brwstr N-55	800	10,500
Gilmour Drlg Co	*3	dsl or gas	325	Natl-T32	400	6,000
Hunt Drlg Co Inc	1	gas	1212	Brwstr N-7	732	10,000
J & C Drlg Co	6	gas-btne	550	Natl 50	380	7,500
	8	gas-btne	810	Beth 650	810	12,500
Rhodes & Hicks Drlg Corp	1	gas-btne	370	Frnks 137	200	5,500
Ochiltree County						
Arrow Drlg Co	10	gas	560	Emsco 500		9,000
	28	gas	840	Natl 50		7,500
Big Chief Drlg Co	24	gas	750	M-CSCO U-15	800	9,500
	36	gas	800	Natl 55	800	11,000
E B Clark Drlg Co	2	gas-btne	750	Wisn Gnt	600	8,500
Dillard-Waltermire Inc	10	gas	600	Wisn Gnt	800	8,000
	15	gas	800	Wisn Atlas	1200	11,000
Falcon Seaboard Drlg Co	18	dsl	975	Wheland B-85	975	10,000
Foree Drlg Co	5	btne	350	"Oilwell" 52-T	426	6,000
FWA Drlg Co Inc	8					9,000
Jack Grace Drlg Co	16	gas-btne	700	Wisn Titan	1200	12,500
	20	gas-btne	625	Wisn Atlas	1200	11,000
Luke Grace Drlg Co	7	dsl	750	Wisn Air Atlas	750	12,500
Lynn Drlg Co	2	gas-btne	425	Natl 75	700	10,000
Moran Bros Inc	4	gas	1000	Wisn Titan	1200	14,000
	11	gas	900	Wisn Gnt	750	10,000
Rowan Drlg Co Inc	10	gas-btne	1020	Beth 450	766	9,000
Wagner & Wyant Drlg Co Inc	4	gas-btne	500	M-CSCO U-15	700	9,000
Warren-Bradshaw Drlg Co	*64	gas-btne		Beth MC 450	700	10,000
Orange County						
Clegg & Hunt	2	stm		Emsco H-54		11,000
Panola County						
Robert M Bass Drlg Contr	3	gas-LPG	400	Wisn Gnt Rdair	600	8,500
Milton Crow Inc	*5	dsl	900	Brwstr N-75	850	11,000
Lunsford Drlg Co	2	LPG	145	Wisn Spr	145	2,500
Parker County						
Jack Grace Drlg Co	17	gas-btne	370	Wisn Gnt	700	8,000
Pecos County						
Alan Drlg Co	*2	gas	406	Wisn Mogul	225	4,000
Bickerstaff & Tibbetts Drlg Co	*2	gas		Brwstr N-4	320	5,500
	*4	gas		U-15	675	7,500
	*6	gas		U-15	675	8,500
Bolin Oil Co & D H Bolin	2	LPG or NG	250	Natl T-12	225	4,500
Capitan Drlg Co Inc	1	gas	700	Emsco GC-500	700	10,000
	2	gas	450	Emsco G-450	450	7,000
	3	gas	500	Natl 50	500	7,500
Delta Drlg Co	36	gas-btne	900	Wisn Titan	900	15,000
Dual Drlg Co	*2	gas	600	Wisn Gnt	700	8,500
Guadalupe Drlg Co	1	gas-btne	700	Ideco M 1000		10,000
Helmerich & Payne Inc	37	gas	1200	"Oilwell" 96	1450	15,000
Carl B King Drlg Co of Tex	10	gas-btne	1000	Natl 75	1000	12,500
	12	gas-btne	1000	Natl 75	1000	12,500
Layton & Newell Drlg Co	1	gas-btne	500	M-CSCO U-15	600	8,000
Parker Drlg Co	43	gas		"Oilwell" 96	1400	15,000
	45	gas		Natl 125	1400	15,000
Raiborn Drlg Co	1	gas	200	R6 Wichtex	185	5,000
Rowan Drlg Co Inc	16	gas-btne	504	Natl 50	660	7,000
Potter County						
Moran Bros Inc	12	gas	350	Crdwll "8"	250	4,000
Reeves County						
Helmerich & Payne Inc	39	gas	1100	"Oilwell" 96	1300	14,000
Hissom Drlg Co	*6	gas-btne		U-34 Unit Rig	650	6,500
Pico Drlg Co	5	gas-btne	356	"Oilwell" A-64-B	356	6,000
Reagan County						
Forest Blackstock Inc	1	gas	700	Emsco GB-350	700	8,000
Bolin Oil Co & D H Bolin	1	LPG or NG	250	Natl T-12	175	4,000
Tri-Service Drlg Co	5	gas	825	"Oilwell" 76	825	10,000
	8	gas	900	"Oilwell" 76	900	10,000
Refugio County						
E. L. Bass Drlg Co	*3	rotary		U-34		7,000
Chiles Drlg Co	2	dsl	300	Ideco H-40	300	6,000
J & C Drlg Co	2	stm	525	Ideal 34-32-9	525	10,000
	3	dsl	629	Natl 50	762	8,000
Roberts County						
Big Chief Drlg Co	33	gas	1250	Natl 55	1250	11,000
Moran Bros Inc	5	gas	1400	"Oilwell" 860	2025	17,000
Runnels County						
Frank Caraway Drlg Co	1	btne-gas	285	Beth S-50	265	5,000
	2	btne-gas	350	Wisn Mgl Trcr	265	5,000
Roy Guffey Drlg Co	4	gas-btne	628	M-CSCO U-15	628	7,500
	6	gas-btne	628	M-CSCO U-15	628	7,500
Low Drlg Co	1	btne		Emsco	290	7,000
Rusk County						
B-M Drlg Co Inc	2	gas	685	Emsco GB-350	500	8,000
Robert M Bass Drlg Contr	1	gas-LPG	500	Wisn Rdair	800	10,000
Carter-Jones Drlg Co	11	gas-btne		Brwstr N-4	280	6,500
Tex-Mex Drlg Co	5	gas-btne	600	M-CSCO U-15	600	9,000
San Patricio County						
Continental Marine Expl Co	2	gas-btne	2120	Natl 110	1340	15,000
Dillard-Waltermire Inc	5	stm	800	Natl 23-9FM	1000	12,000
Miller Bros & Bowling	1	gas-btne	495	Emsco G-300		5,500
Schleicher County						
Fortune Drlg Corp	2	gas	600	M-CSCO U-15	600	7,500
Scurry County						
Forest Blackstock Inc	3	gas	650	Emsco 500	650	9,000
Dual Drlg Co	*1	gas	600	Wisn Gnt	700	8,500
John Grappe Drlg Co	*1	gas	1400	Beth S-60	700	8,000
Robinson Drlg Co (Colo City)	*4	gas	300	Beth S-45-E	175	3,500
Wes-Tex Drlg Co	6	btne	500	M-CSCO U-15	640	8,500
Shackelford County						
Gore Drlg Co	1	dsl	640	Shovel Spl		7,500
	2	dsl	320	Beth		5,000
	3	gas	254	Joy 200-A		2,500/2⅞"
Smith County						
Robert M Bass Drlg Contr	2	gas-LPG	300	Wisn Gnt	300	5,500
B G Byars Power Drlg Co	3	dsl	400	Emsco GA-250T	300	5,500
M J Delaney Co	24	gas-btne	500	Beth M-58	600	9,500
Delta Drlg Co	15	gas-btne	530	M-CSCO U-15	600	8,000
Maxwell Herring Drlg Corp	1					6,000
	3					10,000
Tex-Mex Drlg Co	9	gas	400	Emsco 250	450	5,500
	12	gas		M-CSCO U-15		9,000
Starr County						
Harkins & Co	6	gas-gaso	675	M-CSCO U-15	675	9,500
Milam Drlg Co	1	gas-btne	600	Emsco G-500	600	5,000
Monte Cristo Drlg Corp	1	gas-btne	750	Natl 50-A	700	8,500
	5	dsl	1200	Natl 80-B	1000	12,500
Well Drlgrs Inc	2	gas-btne	1446	Ideco Super 7-11	1446	15,000
Stephens County						
Cooper Drlg Co	1	gas	350	Natl 50	400	6,000
Taylor Expl Co Inc	1	btne		Failing		1,200
	7	btne		Mayhew		1,200
Sterling County						
Rheay & Reynolds Drlg Co	3	gas	400	M-CSCO U-15	1200	6,500
Stonewall County						
Bolin Oil Co & D H Bolin	4	LPG or NG	350	Wisn Rdair Gnt	350	7,500
Cooper Drlg Co	2	gas	600	Wisn Gnt	600	8,000
FWA Drlg Co Inc	1					7,500





CUT MUD COSTS TWO-WAYS WITH "RUMBA" SHALE SHAKERS

"RUMBA" Shale Shakers with De-Sanders will cut your drilling mud costs by removing more shale and sand to give you a cleaner mud, while saving you money on your shaker investment.

"RUMBA" handles more mud, more efficiently because the mud is evenly channeled from the spreader box and directed over the *full width* of the screened surface area. To insure maximum removal of cuttings, "RUMBA" Shakers are equipped with five foot lateral frame struts and distribute an equal amount of vibration to every inch of the under-slung, stainless steel screen cloth. The under-slung vibrating screen cloth also removes tons of sand that would otherwise damage pumps, pistons, liners, and valves. The cloth is attached with stainless steel hooks that will not rust or corrode. Hooks last the life of the screen.

"RUMBA'S" new and improved design of mud tank, by-pass and return mud outlet has been enlarged to handle the flow of the largest pumps in the industry. "RUMBA" Shale Shakers are built stronger. Require less maintenance than any other type of shale shaker.

"RUMBA" Shale Shakers and De-Sanders are sold through supply stores everywhere.

HUTCHISON MANUFACTURING CO.

P. O. BOX 9335 • HOUSTON 11, TEXAS

A SUBSIDIARY OF REVERE ELECTRIC MANUFACTURING CO.

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Roy Guffey Drlg Co	2	gas-btne	628	M-CSCO U-15	628	7,500
Johnson-Gadbois Drlg Co	*5	LP	200	Wisn Mogul	240	4,500
W B Omohundro	10	btne	300	Wisn spr 3B Rdaire		4,500/3½"
Wes-Tex Drlg Co	9	btne	460	Emsco GA-500	570	9,000
Sutton County						
Wes-Tex Drlg Co	1	btne	250	Natl 50	650	6,000
Taylor County						
Dixon Drlg Co	3	gas	400	Natl 50	600	8,000
Hack Drlg Co	4	btne			161	2,500
John Haseman Inc	1	gas-btne	350	Ideco H-35D	300	6,000
Herb Expl Co	2	btne		Failing 1500		1,500/2⅛"
	3	btne		Failing 1500		1,500/2⅛"
Low Drlg Co	3	btne		Wilson	165	2,500
Norman Drlg Corp	2	dsl	330	M-CSCO U-10	350	5,000
Rheay & Reynolds Drlg Co	8	gas	200	Brwstr N-4	200	3,500
Sojourner Drlg Corp	1	btne	218	M-CSCO U-15	555	7,500
West Central Drlg Co	9	gaso-btne	225	Spencer	145	4,200
Terrell County						
Parker Drlg Co	49	gas		Natl 125	1400	15,000
Rowan Drlg Co Inc	29	gas-btne	1200	Natl 100	1480	14,000
Terry County						
Durham Drlg Co Inc	1	gas	650	Unit U-15	650	8,000
Throckmorton County						
Hack Drlg Co	1	btne		M-CSCO U-15	412	8,500
E W Moran Drlg Co	4	gas	500	Wisn Gnt	650	7,500
Tom Green County						
Fortune Drlg Corp	1	gas	512	Beth S-55C	512	7,500
Thomas & Billups Drlg Co	7	btne	820	Wisn Gnt	820	9,000
Upton County						
Dixilyn Drlg Corp	4	gas	950	Natl 80	950	14,000
Empire Drlg Co	*5	gas	350	Unit U-15	500	8,500
Robinson Bros Drlg Co	3	gas	300	Brwstr N-55	500	6,500
Val Verde County						
Helmerich & Payne Inc	48	gas-btne	1200	Natl 110	1300	15,000
Van Zandt County						
Arrow Drlg Co	5	gas	1250	Emsco		14,000
M J Delaney Co	30	gas-btne	500	Beth 1013	1200	15,000
Delta Drlg Co	42	dsl	600	M-CSCO U-15	550	8,500
Maxwell Herring Drlg Corp	5					14,000
Tex-Mex Drlg Co	10	gas		Emsco GB-500		9,000
Victoria County						
Columbia Drlg Co	*5	dsl	750	M-CSCO U-15	450	8,500
Harkins & Co	7	dsl	600	M-CSCO U-15	600	9,500
J & C Drlg Co	7	gas-btne	892	Emcso GB500-34	645	9,000
Ward County						
Bolin Oil Co & D H Bolin	7	LPG or NG	250	Beth S-50	225	4,000
Pico Drlg Co	2	gas-btne	475	Brwstr N-7	475	8,500
Wharton County						
Edman Drlg Co	*4	dsl	500	Mid-Con U-34	300	5,000
Hull Oil Co	1	btne	140	Wlkr-Nr R-2	135	2,150
E W Moran Drlg Co	1	gas	560	M-CSCO U-15	560	7,500
W B Omohundro	9	btne	550	Wisn Gnt		5,500
Willacy County						
Monte Cristo Drlg Corp	4	gas-btne	600	TIW CT-5	700	8,000
Wilbarger County						
FWA Drilling Co Inc	15					3,000
	17					3,500
Medford Drlg Co	1	gas-btne	200	Wichtex R-3	200	3,000
E W Moran Drlg Co	7	gas	225	Crdwll L	225	4,500
Wilson County						
Field Drlg Co	4	dsl	520	Beth Breeze	260	6,800
Winkler County						
Big West Drlg Co	11	gas-btne	500	M-CSCO U-20	900	14,000
Camden Drlg Co	1	dsl	300	Natl T-20	300	5,000
Danforth Drlg Co	1	dsl	320	Ideco H-30	350	5,000
Dillard-Waltermire Inc	13	gas	800	Wisn Titan	1200	12,000
FWA Drilling Co Inc	7					12,000
Leatherwood Drlg Co	4	gas	500	Natl T-20	500	6,000
Parker Drlg Co	42	gas		Natl 100	1400	14,000
Rowan Drlg Co Inc	2	gas-btne	840	Natl 75	1120	11,000
Wise County						
Alan Drlg Co	*1	gas	500	Wisn Gnt	600	7,000
Bolin Oil Co & D H Bolin	5	LPG or NG	250	Wisn Nogul	175	4,000
	6	LPG or NG	350	Wisn Rdair Gnt	250	6,500
Jack Grace Drlg Co	19	gas-btne	370	Wisn Gnt	350	5,000
H O Grace Drlg Co	4	btne				7,500
John W Harris Drlg Co	1	gas	500	Hou Prtble	450	6,500
	2	gas	500	Emsco GC-500	500	8,000
John Haseman Inc	2	gas-btne	150	Wisn Super	150	3,500
	4	gas-btne	150	Crdwll K-200	150	3,500
Holliman Drlg Co	3	gas	255	M-CSCO U-15	600	7,500

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
E W Moran Drlg Co	5	gas	370	Natl 50	650	7,500
Orm Drlg Co	*15	dsl			600	7,500
Walters Drlg Co Inc	12	dsl		Mayhew 1000	300	400/2⅛"
Wood County						
Ace Drlg Co	2	gas-btne	500	Emsco G-500	630	9,000
Carter-Jones Drlg Co	10	gas-btne		Wlsn Gnt	500	7,000
M J Delaney Co	19	gas-btne	600	Emsco J-1250	1200	15,000
Delta Drlg Co	22	gas-btne	530	M-CSCO U-15	600	8,000
	40	gas-btne	325	Wlsn Rdr Gnt	690	8,000
	44	gas-btne	1300	Brwstr N-95	1300	14,000
Parker Drlg Co	38	gas		Natl 100	1000	14,000
Yoakum County						
Empire Drlg Co	*2	gas	550	Brwstr N-7	750	9,500
Fred Pool Drlg Co	1	gas	580	M-CSCO U-15	600	7,500
Young County						
Jess P Cross Drlg Contr	*1	gas-btne	225	Wlsn Gnt	200	4,800
R W Darden Drlg Co	1	gas	145	Wichtex R-3	140	3,000
H O Grace Drlg Co	1	btne				6,000
A K Knappenberger Drlg	*AFK	gas	14000	Emsco GA500	450	7,500
	*K&H	gas	8000	Wlsn	370	4,800
Lin-Mour Drlg Co	1	gas	315	Wlsn Mogul	400	4,600
Man Drlg Co	*5	gas	350	Wlsn Gnt	225	5,500
Gene McCutchin Drlg Co	*5	gas	275	Wlsn Gnt	275	6,500
Meredith Drlg Co	2	gas-btne	675	Wlsn Gnt 3x225	NK Wauk	7,500
Oney Drlg Co	*5	LPG	200	Crdwll "S"	166	4,500
Varner-Neill Drlg Co	*1	gas	500	Wlsn Gnt	450	6,000
Zapata County						
Well Drlgrs Inc	1	gas-btne	1446	Brwstr N-95	1446	16,000
Zavala County						
Dixon Drlg Co	*4	dsl	200	Natl T-12	200	4,000
West Central Drlg Co	5	gaso-btne	1000	Unit 15	700	9,000
UTAH						
Duchesne County						
Exploration Drlg Co	11	gas	800	Beth St-60	480	8,000
Grand County						
Camay Drlg Co	3	dsl	560	Natl 50-A	450	8,500
Will I Lewis Drlg Co	5	dsl	1200	"Oilwell" 76	1200	13,500
Montezuma County						
Calvert Drlg Inc	23	dsl	350	Ideco H-525	600	8,500
San Juan County						
Calvert Drlg Inc	20	dsl	350	Ideco H-525	600	8,500
	28	gas	1650	Natl 80-B	1650	12,500
	29	dsl	1000	Natl 50A	1000	10,000
Kent Drlg Co	1	gas	1050	Natl 75 CE	1050	10,500
R L Manning Co	4	gas-btne	600	Emsco 450	450	7,000
Moran Bros Inc	1	gas	1000	"Oilwell" 760	1200	14,000
	10	gas	600	Emsco GA-350	550	8,000
Rhodes Drlg Co	5	gas	450	M-CSCO U-15	675	9,000
Warren-Bradshaw Drlg Co	*38	gas-btne		Unit U-15	750	8,500
Sanpete County						
Pioneer Drlg Co Inc	*5	dsl	850	Emsco J-750	1000	12,000
Uintah County						
Gist Expl Co	3	gas-btne	1200	Unit Rig 20	1425	12,000
Hewit-Gulick Drlg Co	1	dsl	970	Natl 50-A	600	8,000
	3	dsl	855	Natl 50-A	900	9,000
Kerr-McGee Oil Ind Inc	1	gas	825	M-CSCO U-15	832	10,000
	23	gas	650	Natl 50	556	9,000
Warren-Bradshaw Drlg Co	*40	gas-btne		Unit U-15	750	8,500
WASHINGTON						
Aberdeen County						
Canbridge Corp Ltd	2	dsl	300	Frnks SAL	296	6,000
WEST VIRGINIA						
Greenbrier County						
S W Jack Drlg Co	4	gas	1000	M-CSCO U-15	1000	10,000
Pendleton County						
Delta Drlg Co	39	gas-btne	500	Natl 75	1000	9,500
Randolph County						
Delta Drlg Co	29	dsl	750	Emsco J-750	750	12,000
WYOMING						
Albany County						
Exploration Drlg Co	*6	gas	310	Beth S-50	225	5,500
Big Horn County						
Big Horn Drlg Co Inc	1	dsl	320	Brwstr N-4	290	5,500
C E Brehn Drlg & Prod	W3	gas	532	Wlsn Mogul Super	532	7,200
Exploration Drlg Co	16	gas	725	Nat 75	600	9,000

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Campbell County						
Delta Drlg Co	23	dsl	520	Emsco GA-500	500	8,000
Exeter Drlg Co	1	dsl	325	Emsco GA-350	425	7,000
Pioneer Drlg Co Inc	*4	dsl	750	Emsco GB-500	600	9,000
True Drlg Co	6	gas-LPG	1000	Beth Twister	750	8,500
Carbon County						
Fitzpatrick Drlg Co Inc	3	dsl-btne	300	Natl 50-A	200	5,500
Roden & McRae Drlg Corp	2	dsl	265	Emsco GA-300	270	4,500
Converse County						
R L Manning Co	11	gas-btne	1080	Emsco J-1000	1305	13,000
Crook County						
Garvey Drlg Co	19	dsl	300	Wlsn Rdair	450	7,000/3½"
True Drlg Co	6	gas-LPG	1000	Beth Twister	750	8,500
	8	gas-LPG	750	Nat 50	500	7,500
	14	gas-LPG	1000	Nat 50-A	700	9,500
Fremont County						
Mountain States Drlg Co Inc	3	gas-dsl	600	Natl 50-A	—	7,500
Roden & McRae Drlg Corp	5	gas	360	Emsco GA-250 T	425	6,500
	6	dsl	275	Frnks Rckt TD44	275	2,000
Rowan Drlg Co Inc	31	gas-btne	900	Natl 75	1149	11,000
J D Sprecher	6	dsl	750	Emsco A-550	750	10,000
Hot Springs County						
R L Manning Co	2	gas-btne	375	Emsco 300	300	5,500
	10	gas-btne	1275	Emsco J-750	1125	11,000
Johnson County						
R L Manning Co	8	dsl	550	Emsco G-500	550	7,500
True Drlg Co	10	gas-LPG	1000	U-15	675	8,500
Lincoln County						
Fitzpatrick Drlg Co Inc	4	gas-btne	900	Wlsn Titan Rdr	900	12,500
Gist Expl Co	2	gas-btne	800	Brwstr N-75	950	10,000
Hewit-Gulick Drlg Co	2	dsl	970	Natl 80	900	12,000
Natrona County						
Arrow Drlg Co	14	dsl	600	Emsco 250	—	4,000
Bueno Drlg Co	1	dsl	720	Natl T-20	300	5,000
Garvey Drlg Co	17	dsl	300	Wlsn Rdair	450	7,000/3½"
Fitzpatrick Drlg Co Inc	6	dsl	300	Natl T-12-S	300	4,500
R L Manning Co	17	gas-btne	765	Emsco GC-500	840	10,000
J D Sprecher	2	dsl	900	Emsco J-750	900	10,500
	4	dsl	1000	Natl 80-B	1000	14,000
True Drlg Co	*7	dsl	350	Failing 66	185	3,000
Park County						
R L Manning Co	5	gas-btne	750	Emsco G-500	750	8,000
	16	gas-btne	650	Natl T-32	450	6,000
Rowan Drlg Co Inc	24	gas-btne	504	Natl 50	1077	8,500
Powder River						
Gabe McCall Drlg Co	2	dsl	600	Emsco GB-250	500	6,500
Sheridan County						
True Drlg Co	12	gas-LPG	1100	Wlsn Gnt	800	11,000
Sublette County						
Fitzpatrick Drlg Co Inc	1	gas-btne	550	M-CSCO U-15	550	8,250/4"
	5	gas-btne	600	Natl T-20	600	8,500
Gist Expl Co	4	gas-btne	620	Wlsn Gnt Rdr	750	8,000
Kent Drlg Co	2	gas	—	Natl 50	1200	7,500
Mountain States Drlg Co Inc	11	gas-dsl	1000	Natl 80-B	—	12,500
Sweetwater County						
Exploration Drlg Co	1	gas	310	Beth S-60	450	7,000
Falcon Seaboard Drlg Co	39	gas	770	Emsco G-500	770	9,000
	43	dsl	300	Beth S-55	325	6,500
Hewit-Gulick Drlg Co	4	dsl	370	Natl T-32	356	6,000
R L Manning Co	15	dsl	540	Emsco GB-250	340	6,000
Mountain States Drlg Co Inc	2	gas-dsl	1000	Emsco J-750	—	10,000
Pioneer Drlg Co Inc	*6	dsl	850	Emsco GB-800	1000	12,000
J D Sprecher	5	dsl	350	Brwstr N-45	350	6,500
Washakie County						
Big Horn Drlg Co Inc	3	gas	600	Emsco GB-250	360	6,500
Weston County						
Delta Drlg Co	43	dsl	400	M-CSCO U-10	450	6,000
Exploration Drlg Co	8	gas	725	M-CSCO U-15	600	8,000
Lohmann-Johnson Drlg Co Inc	4	dsl	300	M-CSCO U-15	440	5,500
Olds & Wrather Drlg Co	1	dsl	300	Wlsn Rdair Mgl	300	5,000
	2	btne	675	Emsco GB-350	675	7,500
	3	dsl	400	Frnks Comet 50	250	5,000
	4	dsl	240	Wlsn Gnt	300	4,000
Prairie Drlg Co Inc	1	gas	—	Crdwll RL Spdr	200	11,000
True Drlg Co	*4	gas-LPG	650	Emsco 250	400	6,000
	9	gas-LPG	1200	U-40	1200	13,000
	11	gas-LPG	1100	Nat 75	1100	11,000

Canadian Rotary Drilling Contractors

A

Arrow Drlg Co 201 Oil Exchange Bldg Calgary Alberta Canada

B

Bawden Peter Drlg Ltd 640 Seventh Ave Calgary Alberta Canada
Bernco Drlg Ltd 507 Lancaster Bldg Calgary Alberta Canada
Big Horn Drlg Ltd 6530 100th St Edmonton Alberta Canada
Big Indian Drlg Co Ltd 216 Blow Bldg 513 8th Ave W Calgary Alberta Canada
Border Drlg Co Ltd Box 40 Lloydminster Alberta Canada
Brinkerhoff Drlg Co Ltd 1001 Mobil Oil Bldg Calgary Alberta Canada
Brown Drlg Ltd 10509 81st Ave Edmonton Alberta Canada

C

Cactus Drlg Corp Ltd Box 853 Calgary Alberta Canada
Can American Drlg Ltd 320 Seventh Ave W Calgary Alberta Canada
Canbridge Corp Ltd Calgary Alberta Canada
Cascade Drlg Co Ltd 330 Ninth Ave SW Calgary Alberta Canada
Central Del Rio Oils Ltd Drlg Div 224 9th Avenue West Calgary Alberta Canada
Chupp Well Serv Ltd 525 A 7th Ave SW Calgary Alberta Canada
Commonwealth Drlg Co Ltd 122 Eigth Ave W Calgary Alberta Canada
Coultis Drlg Ltd 1724 Suffolk St Calgary Alberta Canada

D

Double-A Drlg Co Ltd 709 Eighth Ave W Calgary Alberta Canada
Duke Drlg Co Ltd 239 Eighth Ave W Calgary Alberta Canada

G

Gardner Bros Drlg Co Ltd 309 7th Ave SW Calgary Alberta Canada
General Petroleum of Canada Ltd 224 Ninth Ave W Calgary Alberta Canada
Gustavson Drlg Co Ltd 203 Empire Bldg Calgary Alberta Canada

H

Hi-Tower Drlg Co Ltd 400 Lancaster Bldg Calgary Alberta Canada
Hunter Drlg Ltd 602 Seventh Ave W Calgary Alberta Canada

L

L & J Drlg Ltd 7 Empire Bldg Calgary Alberta Canada
Lee R E Drlg Co Ltd 300 Lancaster Bldg Calgary Alberta Canada
Lohmann-Johnson Drlg Co Ltd 208 Bamlett Bldg Calgary Alberta Canada

M

Mortenson Drlg 8706-83 Avenue Edmonton Alberta Canada

P

Parker Drlg Co of Canada Ltd 409 Eighth Ave W Calagry Alberta Canada
Pennant Drlg Co Ltd 132-9 Street SW Calgary Alberta Canada
Petrolia Drlg Co Ltd 1410 4th St SW Calgary Alberta Canada
Porter Drlg Ltd 304 Brent Bldg Regina Saskatchewan Canada
Precision Drlg Co Ltd 1134 Eighth Ave W Calgary Alberta Canada

R

Reading & Bates Drlg Co Ltd Royal Bk Bldg Calgary Alberta Canada
Regent Drlg Co Ltd Box 421 Edmonton Alberta Canada
Rine Drlg Co of Canada Ltd 534 8th Ave SW Calgary Alberta Canada
Ryland Drlg Ltd Box 608 Edmonton Alberta Canada

S

S & T Drlg Co Ltd 10852 82nd St Edmonton Alberta Canada

T

Trinity Canadian Drlg Co 1001 F R Webster Bldg 237 Seventh Ave W Calgary Alberta Canada

Canadian Contract Rotary Drilling Rigs

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
ALBERTA PROVINCE						
Big Indian Drlg Co Ltd	10	gas		Mayhew		2,000/2⅛"
Hi-Tower Drlg Co Ltd	1	dsl	525	"Oilwell" 66	850	10,000
	3	dsl	525	"Oilwell" 66	800	9,500
	4	dsl	350	Natl 50A	600	8,500
	6	dsl	755	"Oilwell" 76	900	12,000
	7	dsl	525	"Oilwell" 66	875	10,000
	8	dsl	570	Unit Rig 15	600	7,000
	9	dsl	285	Crdwll D	300	5,500
	10	dsl	755	"Oilwell" 76	1000	12,000
R E Lee Drlg Co Ltd	*1	dsl	270	Natl T-20	270	4,500
Lohmann-Johnson Drlg Co Ltd	2	dsl	218	M-CSCO U-15	500	9,000
Athabasca						
Canbridge Corp Ltd	*9	dsl	300	Crdwll L	200	5,000
Borland River						
General Pet of Canada Ltd	7	dsl	1400	Natl 80-B	1300	13,000
	18	dsl	1400	Natl 80-B	1400	13,000
Bigdray						
Commonwealth Drlg Co Ltd	3	dsl	690	Natl 50	600	6,500
Big Valley						
Canbridge Corp Ltd	11	dsl	300	Emsco G-300	300	6,000
Bindloss						
Big Horn Drlg Ltd	2	dsl	250	Crdwll L	180	3,500
Bragg Creek						
Duke Drlg Co Ltd	6	dsl	850	M-CSCO U-20	1386	15,000
Brazeau						
Duke Drlg Co Ltd	7	dsl	850	M-CSCO U-20	1386	15,000
Buck Lake						
General Pet of Canada Ltd	1	dsl	400	Natl 50-A	525	7,500
Carson Creek						
Regent Drlg Co Ltd	9	dsl	750	Brwstr N-75	780	10,000
Carstairs						
Arrow Drlg Co	6	dsl	250	Emsco GB-350	480	7,000
	8	dsl	550	Emsco GB-350	480	7,000
Commonwealth Drlg Co Ltd	14	dsl	580	Ideco H-40D	660	6,500
Gustavson Drlg Co Ltd	3	dsl	275	Ideco H-40	300	6,500
Coesford						
Cascade Drlg Co Ltd	6	dsl	556	Natl T-20	233	4,500
	16	dsl	278	M-CSCO U-34	311	5,000
General Pet of Canada Ltd	12	dsl	400	Natl T-20	250	4,800
Chard						
Precision Drlg Co Ltd	4	dsl	278	Natl T-20	278	5,500
Chip Lake						
Arrow Drlg Co	19	dsl	250	Emsco GB-350	480	7,000
Coalspur						
Peter Bawden Drlg Ltd	21	dsl	1680	"Oilwell" 96	1680	18,000
Coronation						
Brown Drlg Ltd	2	dsl	550	Natl 50	550	7,500
Coutts						
Gardner Bros Drlg Co Ltd	15	dsl	1600	"Oilwell" 96	2000	18,000
Crossfield						
Peter Bawden Drlg Ltd	23	dsl	627	Emsco GB-350	627	7,000
Commonwealth Drlg Co Ltd	8	dsl	690	Natl 50-A	600	8,500
General Pet of Canada Ltd	6	dsl	400	Natl 50-A	500	7,000
	14	dsl	400	Crdwll OA	500	7,000
Gustavson Drlg Co Ltd	1	dsl	500	Natl 50	500	7,500
Regent Drlg Co Ltd	6	dsl	750	Brwstr N-75	780	10,000
Cynthia						
Brinkerhoff Drlg Co Ltd	12	dsl	300	Natl T-32	300	6,000
Decalta						
Duke Drlg Co Ltd	9	dsl	500	M-CSCO U-15	650	9,000
Drayton Valley						
Commonwealth Drlg Co Ltd	11	dsl	260	Ideco H-40D	300	5,500
Drumheller						
Commonwealth Drlg Co Ltd	7	dsl	750	Natl 50	530	6,500
Edmonton						
Peter Bawden Drlg Ltd	3	dsl	278	Crdwll S	160	4,500
	4	dsl	227	Crdwll RL	210	4,500
	14	dsl	142	Crdwll Mobilhst	100	2,500
Mortenson Drlg	3	gas		Failing	110	1,000
Edson						
Gardner Bros Drlg Co Ltd	7	dsl	970	Natl 100	1000	13,000
Enchant						
General Pet of Canada Ltd	20	dsl	400	Emsco GB-250T	275	5,000
Eyremore						
General Pet of Canada Ltd	21	dsl	250	M-CSCO U-34	250	4,800
Farrier						
General Pet of Canada Ltd	5	dsl	1400	Natl 80-B	1400	13,000

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Fort Assiniboine						
Double-A Drlg Co Ltd	12	dsl	800	Ideco H-525	530	9,000
Gilby						
Arrow Drlg Co	4	dsl	730	Emsco GB-350	600	7,000
Rine Drlg Co of Canada Ltd	1	dsl	300	Brwstr N-45-M	230	7,500
Golden Spike						
General Pet of Canada Ltd	19	dsl	400	Natl T-32	275	5,500
Grand Prairie						
Parker Drlg Co of Canada Ltd	8	dsl	500	Natl 50-A	700	7,500
Grimshaw						
Duke Drlg Co Ltd	2	dsl	650	Natl 50	650	8,000
Grizzly						
Reading & Bates Drlg Co Ltd	4	dsl	1200	NSCO 80-B	1200	14,000
Hamilton Lake						
Rine Drlg Co of Canada Ltd	3	dsl	220	Crdwll L Trl	248	4,000
Harmatton						
Commonwealth Drlg Co Ltd	9	dsl	1020	Ideco 700	940	10,000
	28	dsl	920	Natl 55	1000	10,000
General Pet of Canada Ltd	3	dsl	1000	Natl 55	1000	10,000
Regent Drlg Co Ltd	10	dsl	480	Unit 36	480	8,500
Harmon Valley						
Commonwealth Drlg Co Ltd	10	dsl	550	Ideco H-35D	300	6,500
Hines Creek						
Trinity Canadian Drlg Co	7	dsl	875	Emsco GC-500	720	10,000
Hurran						
Cactus Drlg Corp Ltd	4	dsl	215	Emsco GB-160	275	4,000
Jarrow						
Big Horn Drlg Ltd	3	dsl	300	Crdwll I-350	300	4,500
Jenner						
Precision Drlg Co Ltd	3	dsl	278	Ideco H-30-D	300	5,500
Joffe						
Cascade Drlg Co Ltd	7	dsl	556	Natl 50-A	556	7,500
Judy Creek						
Peter Bawden Drlg Ltd	18	dsl	1290	Natl 100	1290	13,000
Brinkerhoff Drlg Co Ltd	18	dsl	625	Emsco GC-500	846	10,000
Commonwealth Drlg Co Ltd	19	dsl	735	Natl 50-A	790	9,500
Parker Drlg Co of Canada Ltd	7	dsl	600	Natl 55	670	9,000
Pennant Drlg Co Ltd	4	dsl	1000	Crdwll O	650	9,500
Regent Drlg Co Ltd	24	dsl	720	Brwstr N-7	520	9,000
S & T Drlg Co Ltd	3	dsl	600	Natl 55	1083	9,000
Kaybob						
Arrow Drlg Co	21	dsl	1250	Emsco J-1250	1400	14,000
Peter Bawden Drlg Ltd	26	dsl	834	"Oilwell" 76	834	11,500
Brinkerhoff Drlg Co Ltd	21	dsl	850	Emsco GB-800	1269	13,500
Gustavson Drlg Co Ltd	6	dsl	1000	Emsco A-550	1000	11,000
Kaydee						
Brinkerhoff Drlg Co Ltd	22	dsl	900	Natl 110	1450	15,000
Keystone						
Peter Bawden Drlg Ltd	5	dsl	454	Natl T-32	278	6,500
Brown Drlg Ltd	1	dsl	250	Crdwll S	180	4,500
Knobhill						
Pennant Drlg Co Ltd	2	dsl	1155	Brwstr N-7	755	8,500
Ledue						
Ryland Drlg Ltd	2	dsl	670	Natl 50	690	7,500
Little Paddle River						
Petrolia Drlg Ltd	11	dsl	950	M-CSCO U-40	1050	12,000
Lobstick						
Brinkerhoff Drlg Co Ltd	16	dsl	370	Emsco GA-350	450	7,500
Meekwap						
Duke Drlg Co Ltd	5	dsl	700	M-CSCO U-20	1386	15,000
Morinville						
Big Horn Drlg Ltd	1	dsl	300	Crdwll S-350	300	5,000
Nordegg						
Parker Drlg Co of Canada Ltd	9	dsl	1260	Natl 110	1890	16,000
Oyen						
Bernco Drlg Ltd	*1	dsl	350	Frnks 350	—	4,000
Precision Drlg Co Ltg	14	dsl	278	Natl T-12	300	4,500
Peace River						
Canbridge Corp Ltd	*3	dsl	380	Crdwll Trl	380	6,000
General Pet of Canada Ltd	25	dsl	375	Emsco GA-250-T	275	5,500
Pembina						
Peter Bawden Drlg Ltd	1	dsl	415	Natl T-32	305	5,500
	12	dsl	278	Natl T-12	159	4,000
Cactus Drlg Corp Ltd	1	gas-btne	450	Brwstr N-55	450	7,000
	3	dsl	420	Natl T-32	280	6,000
Cascade Drlg Co Ltd	3	dsl	556	Natl 50	556	6,500
	8	dsl	556	Natl 50	556	6,500
	9	dsl	—	Natl T-32	—	5,500
	10	dsl	556	Natl 50	556	6,500
Commonwealth Drlg Co Ltd	13	dsl	630	Emsco GA-350	720	6,500
	17	dsl	630	Emsco GB-350	720	6,000
	25	dsl	425	M-CSCO U-34D	300	5,500
Gustavson Drlg Co Ltd	2	dsl	500	Natl T-32	250	6,500
Hunter Drlg Ltd	3	dsl	450	Crdwll	260	6,000
Parker Drlg of Canada Ltd	11	dsl	400	Natl 50	500	6,500
Petrolia Drlg Ltd	7	dsl	250	Natl 50	365	7,500
	10	dsl	300	M-CSCO U-34D	300	5,500
Regent Drlg Co Ltd	1	dsl	260	Brwstr N-4	260	6,000
	26	dsl	260	Ideco H-40	260	7,500
	29	dsl	260	Brwstr N-4	260	6,000
	30	dsl	260	Ideco H-40	260	6,000
Ryland Drlg Ltd	1	dsl	600	Emsco 450	640	7,500
	3	dsl	320	Natl T-32	320	6,000
S & T Drlg Co Ltd	1	dsl	440	Natl 50-A	648	8,000
	2	dsl	220	Nat T-32	250	6,000
			180			
Pincher Creek						
Brinkerhoff Drlg Co Ltd	19	dsl	850	Emsco A-800	1269	14,000
	8	dsl	900	Natl 110	1200	15,000
Pine Creek						
Pennant Drlg Co Ltd	5	dsl	1050	M-CSCO U-40	900	11,500
Red Deer						
Chupp Well Serv Ltd	2	—	—	Crdwll RL-709	—	10,000
Rimby						
Peter Bawden Drlg Ltd	25	dsl	556	"Oilwell" 66	556	8,000
Rocky Mountain						
Hunter Drlg Ltd	2	dsl	900	Crdwll J-700	1150	10,000
Rocky Mountain House						
Parker Drlg Co of Canada Ltd	5	dsl	420	Natl 50	420	7,000
	6	dsl	420	Natl 50	420	6,500
Regent Drlg Co Ltd	7	dsl	1200	Natl 125	1500	15,000
Sedalia						
Canbridge Corp Ltd	*1	dsl	380	Crdwll Trlrg	380	6,000
Sheerness						
Precision Drlg Co Ltd	5	dsl	278	Unit U-34D	300	5,000
Simonette						
Peter Bawden Drlg Ltd	15	dsl	834	M-CSCO U-40	834	11,500
Canamerican Drlg Corp Ltd	*3	dsl	700	Nat 80-B	975	13,000
Cascade Drlg Co Ltd	12	dsl	1350	Natl 80-B	1350	14,000
	14	dsl	1350	M-CSCO U-20	1350	14,000
General Pet of Canada Ltd	23	dsl	625	Natl 50-A	500	7,000
Reading & Bates Drlg Co Ltd	2	dsl	1000	NSCO-55	1000	12,000
Standard						
Precision Drlg Co Ltd	12	dsl	278	Brwstr N-4	300	5,500
Stettler						
Double-A Drlg Co Ltd	11	dsl	320	Ideco H-30	300	5,000
	13	dsl	320	Ideco H-40	300	6,500
Sturgeon Lake						
General Pet of Canada Ltd	16	dsl	1100	Natl 55	1000	10,000
Sundry						
General Pet of Canada Ltd	17	dsl	1325	Natl 55	1050	10,000
Swan Hills						
Peter Bawden Drlg Ltd	6	dsl	720	M-CSCO U-36A	722	8,500
	7	dsl	832	Natl 55	832	9,500
Brinkerhoff Drlg Co Ltd	15	dsl	500	Natl 50-A	600	8,500
Canbridge Corp Ltd	4	dsl	600	Emsco GB-500	600	9,000
	12	dsl	670	Emsco GB-500	670	9,000
Cascade Drlg Co Ltd	1	dsl	556	Natl 50	556	6,500
	5	dsl	556	Natl 50 A	556	7,500
	17	dsl	1190	Natl 75	1190	12,000
Commonwealth Drlg Co Ltd	16	dsl	800	Emsco GB-350	720	7,000
	21	dsl	1250	Ideco 7-11	900	10,500
	27	dsl	870	Natl 50A	660	9,000
Parker Drlg Co of Canada Ltd	2	dsl	800	"Oilwell" 76	1275	11,500
	12	dsl	650	"Oilwell" 66	800	9,000
Pennant Drlg Co Ltd	1	dsl	1050	M-CSCO U-40	775	11,500
Reading & Bates Drlg Co Ltd	1	dsl	1000	NSCO 75	1000	10,000
	3	dsl	1000	NSCO 75	1000	12,000
Regent Drlg Co Ltd	2	dsl	520	Brwstr N-55	520	8,500
	3	dsl	720	Brwstr N-7	520	9,000
	25	dsl	750	Brwstr N-75	780	10,000
Sylvan Lake						
Cactus Drlg Ltd	2	dsl	850	Natl 55	850	9,500
	6	dsl	585	Emsco GB 350	585	7,500
Tofield						
Canbridge Corp Ltd	*5	dsl	200	Crdwll L	200	4,500
Three Hills						
Canbridge Corp Ltd	6	dsl	420	Emsco GB-350	420	7,500
	10	dsl	400	Frnks SAL	400	5,000
Tilley						
Precision Drlg Co Ltd	2	dsl	278	Ideco H-20-D	278	3,500
Turin						
Coultis Drlg Ltd	1	dsl	248	Ideco H-25-D	248	3,500

How Leading

Drilling Contractors Cut Costs

Competition in the contract drilling industry was never keener. Drilling contractors must find new ways to lower their operating costs if they are to show a profit.

It is significant that many of the leading drilling contractors depend on equipment sold and serviced by Jones & Laughlin Supply Division. These leaders discovered long ago that lower first cost did not always mean lower final cost. They know they must use equipment that will give them more performance hours per dollar invested. This is why you'll find quality drilling equipment sold by Jones & Laughlin on the job for these industry leaders.

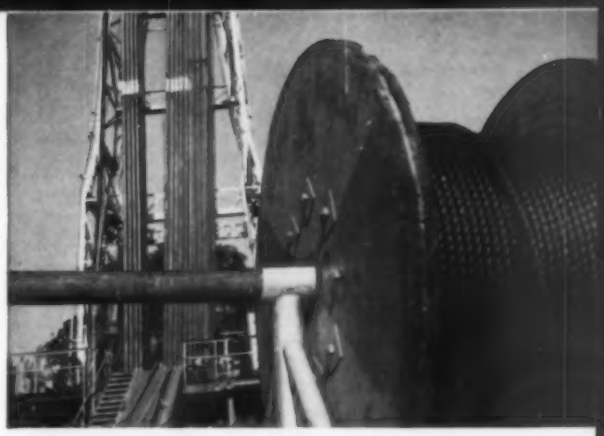
Backed by J&L service with field stocks of expendable supplies and replacement parts, these drilling contractors have cut their costs consistently.

Quality equipment and dependable service can lower *your* operating costs, give you the edge on competition. See your local J&L man today.

Jones & Laughlin

SUPPLY DIVISION – Tulsa

If it's sold by J&L . . . .
It's the best available 101



Because of unusual quality in materials and construction, J&L Wire Rope gives more ton miles. Result: Lower operating costs per foot of hole.

Three Gardner-Denver Mud Pumps on a well in Mississippi. Replacement of all Gardner-Denver parts can be made in the field, and these parts are as near as your J&L Supply store.

No tools needed to lay your temporary galvanized steel lines with McDowell "Fast-Line" Couplings. You save up to 80% installation time. Ask for illustrated booklet.

J&L's quality Blue Ribbon Drill Pipe is preferred by the drillers of the world's deepest wells. The J&L quality control program is the most exacting known. Ask your J&L Supply man for a beautifully illustrated 24-page booklet on oil country tubular goods.

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Valley View						
Gustavson Drlg Co Ltd	5	dsl	420	Natl T-45	420	7,500
Parker Drlg Co of Canada Ltd	3	dsl	765	"Oilwell" 76	1005	12,000
Virginia Hills						
Peter Bawden Drlg Ltd	2	dsl	834	Natl 55	834	10,000
	9	dsl	1000	M-CSCO U-40	1000	11,500
	20	dsl	834	"Oilwell" 76	834	11,500
	22	dsl	834	"Oilwell" 76	834	11,500
Brinkerhoff Drlg Co Ltd	1	dsl	625	Emsco GC-500	846	10,000
Commonwealth Drlg Co Ltd	23	dsl	905	Emsco GC-500	800	9,500
Duke Drlg Co Ltd	8	dsl	500	M-CSCO U-40	670	11,500
Gustavson Drlg Co Ltd	4	dsl	850	Natl 55	850	10,000
Lohmann-Johnson Drlg Co Ltd	1	dsl	550	"Oilwell" 66	550	9,000
Parker Drlg Co of Canada Ltd	13	dsl	840	Crdwll "OA"	840	9,000
Pennant Drlg Co Ltd	6	dsl	1350	M-CSCO U-40	1200	11,500
Regent Drlg Co Ltd	8	dsl	750	Brwstr N-75	780	10,000
Vulcan						
Rine Drlg Co of Canada Ltd	2	dsl	370	Brwstr N-55	720	8,500
Wescott River						
General Pet of Canada Ltd	4	dsl	800	Natl 50-A	650	7,500
Whitecourt						
Canbridge Corp Ltd	7	dsl	780	Crdwll O	780	9,000
Wildcat Hill						
General Pet of Canada Ltd	11	dsl	1400	Natl 80-B	1400	13,000
	15	dsl	1400	Natl 55	1050	10,000
Wildhorse						
Peter Bawden Drlg Ltd	10	dsl	1120	Natl 80-B	1120	14,000
Willesden Green						
Regent Drlg Co Ltd	28	dsl	500	Natl 50-A	520	7,500
Worsley						
Regent Drlg Co Ltd	5	dsl	720	Brwstr N-7	520	8,000
BRITISH COLUMBIA						
Brinkerhoff Drlg Co Ltd	20	dsl	370	Natl 50-A	450	8,500
Hi-Tower Drlg Co Ltd	5	dsl	350	Natl 50	400	5,500
Parker Drlg Co of Canada Ltd	4	dsl	800	"Oilwell" 76	1100	12,500
Alaska Highway						
Cactus Drlg Corp Ltd	5	dsl	600	Emsco GB-500	600	8,500
	7	dsl	600	Emsco GB-350	600	7,500
Commonwealth Drlg Co Ltd	15	dsl	800	Brwstr N-7	600	8,000
	20	dsl	1270	Ideco 7-11	900	10,500
Trinity Canadian Drlg Co	4	dsl	990	Natl 80-B	990	12,000
Beaver River						
Cascade Drlg Co Ltd	2	dsl	610	Natl 100	610	12,000
Blueberry						
Peter Bawden Drlg Ltd	24	dsl	556	M-CSCO U-15	556	7,500
Canbridge Corp Ltd	13	dsl	670	Emsco GA-500	670	9,000
	14	dsl	420	Emsco GB-350	420	7,500
Boundary Lake						
Peter Bawden Drlg Ltd	8	dsl	278	Natl T-32	278	6,500
Brinkerhoff Drlg Co Ltd	23	dsl	250	Natl T-20	300	5,000
Canamerican Drlg Corp Ltd	*1	dsl	500	Natl T-32	335	6,500
Camlake						
Cascade Drlg Co Ltd	19	dsl	1305	Natl 100	750	12,000
Evie Lake						
Brinkerhoff Drlg Co Ltd	14	dsl	370	Emsco GB-500	600	8,500
Flathead						
Commonwealth Drlg Co Ltd	1	dsl	1350	Natl 110	1500	14,000
Fording Mountain						
Commonwealth Drlg Co Ltd	26	dsl	1275	Natl 80-B	1410	12,000
Fort Nelson						
Reading & Bates Drlg Co Ltd	6	dsl	12000	NSCO 80-B	1200	14,000
Fort Saint John						
Canbridge Corp Ltd	*8	dsl	380	Crdwll Trailer	380	6,000
General Pet of Can Ltd	22	dsl	300	Natl T-32	275	5,500
	24	dsl	350	Natl T-32	275	5,500
Jedney						
Cascade Drlg Co Ltd	4	dsl	835	Natl 50-A	556	7,500
Reading & Bates Drlg Co Ltd	5	dsl	750	NSCO 50-A	750	9,000
Julienne Creek						
Commonwealth Drlg Co Ltd	24	dsl	520	Natl 50	600	6,000
Komie Lake						
Cascade Drlg Co Ltd	18	dsl	933	Natl 100	933	12,000
Ketche Lake						
Peter Bawden Drlg Ltd	19	dsl	556	Emsco GB-500	556	8,500
Maxhamish Lake						
Arrow Drlg Co	26	dsl	975	Emsco GB-800	1200	13,000
Moberley Lake						
Commonwealth Drlg Co Ltd	22	dsl	750	Natl 50	530	6,500
Quesnel						
Arrow Drlg Co	7	dsl	975	Emsco GC-500	900	9,000
Trutch						
Cascade Drlg Co Ltd	11	dsl	556	Natl 50	556	6,500
Trinity Canadian Drlg Co	1	dsl	995	Emsco GC-500	770	10,000
	5	dsl	1250	Emsco A-800	1150	15,000
Williams Lake						
Regent Drlg Co Ltd	21	dsl	260	Brwstr N-4	260	9,000/3½" 6,000/4½"
MANITOBA						
Virden						
Commonwealth Drlg Co Ltd	18	dsl	260	Ideco H-25-D	300	4,500
Coultis Drlg Ltd	3	dsl	248	Wgnr Mrhse TD2	150	3,000
NORTHWEST TERRITORY						
Big Indian Drlg Co Ltd	5	gas	—	Mayhew	—	2,000/2⅛"
Brinkerhoff Drlg Co Ltd	26	dsl	—	Emsco GB-350	425	7,000
Parker Drlg Co of Canada Ltd	10	dsl	500	Natl 50-A	700	7,500
McKenzie Highway						
Peter Bawden Drlg Ltd	11	dsl	278	Natl T-32	278	5,000
	16	dsl	556	"Oilwell" 64-B	556	7,500
QUEBEC						
Three Rivers						
Precision Drlg Co Ltd	1	dsl	278	Ideco H-30-D	300	5,500
SASKATCHEWAN						
Big Indian Drlg Co Ltd	14	gas	—	Failing	—	2,000/2⅛"
Border Drlg Co Ltd	1	dsl	175	Crdwll L	150	3,500
Porter Drlg Ltd	*1	dsl	500	Natl T-32	360	6,000
	*2	dsl	720	Natl 50	720	8,000
Alida						
Commonwealth Drlg Co Ltd	4	dsl	260	Ideco H-40-B	300	6,000
	12	dsl	260	Natl T-32	300	5,500
Cabri						
Precision Drlg Co Ltd	7	dsl	550	Ideco 525-D	600	8,000
Carnduff						
Commonwealth Drlg Co Ltd	2	dsl	490	Natl 50	530	6,000
	5	dsl	260	Emsco GA-250-T	310	5,000
Diana Area						
Canamerican Drlg Corp Ltd	*2	dsl	600	Natl 55	650	10,000
Eagle Lake						
Precision Drlg Co Ltd	8	dsl	276	Ideco H-30-D	300	5,500
Esterhazy						
Coultis Drlg Ltd	2	dsl	250	Wisn Torcair	250	4,000
Forjet						
Gen Pet of Canada Ltd	2	dsl	250	Natl T-20	250	4,800
Glen Ewen						
Gen Pet of Canada Ltd	8	dsl	350	Natl T-25	250	5,000
L & J Drlg Ltd	5	dsl	330	Natl 50	440	6,500
Lake Alma						
Commonwealth Drlg Co Ltd	6	dsl	690	Ideco M-750	600	8,500
Lanigan						
Canamerican Drlg Corp Ltd	*6	dsl	600	Natl T-12	275	4,000
Maple Creek						
Precision Drlg Co Ltd	9	dsl	278	Brwstr N-4	300	5,500
Marengo						
Precision Drlg Co Ltd	6	dsl	278	Ideco H-30-D	300	5,500
Midale						
Canamerican Drlg Corp Ltd	*4	dsl	600	Natl T-20	275	5,000
	*5	dsl	500	Natl T-32	335	6,500
	*7	dsl	600	Natl T-20	275	5,000
Parkman						
Hunter Drlg Ltd	1	dsl	450	Crdwll	260	6,000
Regina						
L & J Drlg Ltd	5	dsl	440	Crdwll "S"	300	4,500
Stoolman						
Gen Pet of Canada Ltd	9	dsl	400	Natl T-25	250	5,500
Swift Current						
Precision Drlg Co Ltd	10	dsl	550	Ideco 525-D	600	8,000
	11	dsl	550	Crdwll D	600	6,000
	15	dsl	550	M-CSCO U-34	550	6,000
Torquay						
Regent Drlg Co Ltd	27	dsl	260	Brwstr N-4	260	6,000
Weyburn						
Central-Del Rio Oils Ltd—Drlg Div	1	dsl	500	Natl 50	500	6,500
	2	dsl	285	Crdwll TR-66	245	5,000
Regent Drlg Co Ltd	22	dsl	260	Brwstr N-4	260	6,000
	23	dsl	260	Brwstr N-4	260	6,000
YUKON						
Parker Drlg Co of Can Ltd	1	dsl	800	"Oilwell" 76	1275	11,500

Some Contractors in Foreign Service

Big Chief Drlg Co Box 8837 Oklahoma City 14 Okla
Delta Overseas Drlg Co (Rome Italy) Box 2012 Tyler Tex
Drlg & Expl Co Inc Box 35366 Dallas 35 Tex
Helmerich & Payne Inc First Natl Bldg Tulsa Okla
Kerr-McGee Oil Industries Kerr-McGee Bldg Oklahoma City Okla
Parker Drlg Co 418 Natl Bk of Tulsa Bldg Tulsa 3 Okla
Perforaciones Delta C A Apartado 9138 Caracas Venezuela
Box 2012 Tyler Tex
Walters Drlg Co Inc 4114 McMillan St Dallas 6 Tex

Some Contract Rigs in Foreign Service

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
ARGENTINA						
Kerr-McGee Oil Ind Inc	*CU 1	dsl	110	Wgnr Mrhse E-15-38B	280	3,000
	*CU 2	dsl	110	Wgnr Mrhse E-15-38B	280	3,000
	3	dsl	970	Natl 75	1000	11,500
	28	dsl	970	Natl 75	1000	11,500
	41	dsl	970	Natl 75	1000	11,500
	42	dsl	970	Natl 75	1000	11,500
	52	dsl	500	Emsco GC-350-T	840	6,000
	53	dsl	500	Emsco GC-350-T	840	6,600
AUSTRALIA						
Delta Drlg Co	41	dsl	1300	Natl 130	1400	16,000
BOLIVIA						
Big Chief Drlg Co	29	dsl	1875	Emsco 1250	1815	16,000
	31	gas	1545	Emsco 800	1515	13,500
	37	gas	1875	Emsco 1250	1815	16,000
Kerr McGee Oil Industries Inc	51	dsl	970	Natl 75	1000	11,500
BRITISH HONDURAS						
Kerr-McGee Oil Industries Inc	14	dsl	695	Natl 50	630	9,000
	50	dsl	1000	Natl 55	750	10,000
COSTA RICA						
Drlg & Expl Co Inc	42	dsl	1800	"Oilwell" 96	2000	18,000
IRAQ						
Drlg & Expl Co Inc	—	dsl	1125	Ideco H-525	550	5,000
	—	dsl	1375	Ideco H-525	550	5,000
KINGDOM OF JORDAN						
Parker Drlg Co	46	gas	—	Natl 75	700	10,000
LIBYA						
Drlg & Expl Co Inc	—	dsl	1000	Natl 100	1700	15,000
MEXICO						
Walters Drlg Co Inc (Dallas)	11	gas	150	Mayhew 1000	150	600/2⅛"
PORTUGUESE GUINEA						
Drlg & Expl Co Inc	40	dsl	700	Emsco GB-500	1050	7,500
TURKEY						
Drlg & Expl Co Inc	—	dsl	1250	Natl 80-B	1500	14,000
VENEZUELA						
Helmerich & Payne Inc	61	dsl	—	Natl 125	—	—
	62	dsl	—	Natl 125	—	—
	63	stm	—	Natl 34-10	—	—
	64	stm	—	Natl 34-10	—	—
	65	dsl	—	Natl 50-A	—	—
	66	dsl	—	Natl 125	—	—
	67	dsl	—	Natl 110	—	—
	68	stm	—	Natl 34-10	—	—
Kerr-McGee Oil Ind Inc	V-1	dsl-elec	2000	Emsco A-800-E	1500	13,000
	V-2	dsl-elec	2000	Emsco A-1100-E	1500	16,000
Perforaciones Delta C A (Caracas Venezuela)	1	dsl	260	Ideco H-40-D	400	6,500
	2	dsl	260	Ideco H-40-D	400	6,500
	3	dsl	260	Failing 2066	—	1,500
	4	dsl	260	Ideco H-40-D	400	6,500
	5	stm	1200	Emsco UBLS	1690	15,000
	7 (wo)	dsl	260	Ideco H-30-D	300	4,500
	9	dsl	1000	Emsco GB-800	900	12,000
	10	dsl	260	Crdwll O	450	7,500
	11	dsl	130	Natl T-12	120	2,500
	Bge 12	dsl	1560	Emsco J-1250	1250	15,000
	Bge 13	dsl	1040	Emsco J-1250	1250	15,000
	Bge 14	dsl-elec	2000	Emsco ECB	1200	15,000
	Bge 15	dsl-elec	2000	Emsco ECB	1200	15,000
	Bge 16	dsl-elec	2000	Emsco ECB	1200	15,000
	17	dsl	200	Crdwll R	250	4,500
	18	dsl	200	Crdwll R	250	4,500
	19	dsl	260	Crdwll TR	250	6,000
	20	dsl	260	Crdwll TR	250	6,000
	21	dsl	260	Crdwll TR	250	6,000
	22	dsl	520	Natl 80-B	800	10,000
	23	dsl	520	Natl 100	900	12,000

Offshore Rig Locator

DRILLING CONTRACTORS

Blue Water Drlg Corp 101 Carondelet Bldg New Orleans La
Caldrill Offshore Inc 3400 Loma Vista Rd Ventura Calif
Circle Drlg Co Inc 601 Pioneer Bldg Lake Charles La
Continental Marine Explg Co 911 M & M Bldg Houston 2 Tex
Coral Drlg Co Inc 6100 Camp Bowie Blvd Ft Worth Tex
Delta Marine Drlg Co Box 2012 Tyler Tex
Dixilyn Drlg Corp Box 327 Odessa Tex
Global Marine Expl Co 650 S Grand Ave Los Angeles 17 Calif
Kerr-McGee Oil Industries Inc Kerr-McGee Bldg
Oklahoma City Okla
Louisiana-Delta Offshore Corp 211 Maritime Blvd.
New Orleans 12 La
Movible Offshore Co 743 San Jacinto Bldg Houston 2 Tex
Nicklos Drlg Co 518 1st Natl Bk Bldg Houston 2 Tex
Ocean Drlg & Prod 300-Caribe Bldg New Orleans La
Penrod Drlg Co 1320 Mercantile Security Bldg Dallas Tex
Reading & Bates Offshore Co 610 Saratoga Bldg New Orleans La
Rimrock Tidelands Inc Box 896 New Orleans La
Salt Dome Prod Co 737 Tex Natl Bk Bldg Houston 2 Tex
Sea Drlg Corp 809 Whitney Bldg New Orleans La
The Southeastern Drlg Corp 901 Employers Insurance Bldg
Dallas 2 Tex
Tideland Drlg Co 215 Shell Bldg New Orleans La
Zapata Off-Shore Co 2218 City Natl Bk Bldg Houston Tex

CALIFORNIA

Contractor's Name	Rig, barge Name or No.	Type rig Power	Total HP all main mud pumps	Drwwks Make & Model	Total HP available to Drwwks	Rated depth with 4½" pipe	Max. water depth capacity	Location
Caldrill Inc (Offshore)	D	dsl	1700	OWS 96	1200	16,000	—	Santa Barbara
	E	dsl elec	1200	OWS 860-E	1000	14,000	—	Santa Barbara
Global Marine Expl Co	Cuss 1 Floating Barge	dsl eng	1750	Natl 80-B	1750	12,000	600+	—
	Sm-1 Floating Barge	dsl eng	420	Hopper GTA	420	6,000	600+	—

GULF OF MEXICO

Contractor's Name	Rig, barge Name or No.	Type rig Power	Total HP all main mud pumps	Drwwks Make & Model	Total HP available to Drwwks	Rated depth with 4½" pipe	Max. water depth capacity	Location
Kerr-McGee Oil Ind Inc	40	dsl	2000	Emsco J-1600	2080	15,000	—	OCS-0346 #7, Blk 28, Ship Shoal Area
	45	dsl	1500	Natl 125	1560	15,000	—	State lease 818 #1 Blk 27 W Delta Area
	46	dsl elec	2000	Emsco EDA	1250	20,000	—	OCS-0265 A-1 Blk 33 W Cameron Area
	47	dsl elec	2000	Emsco	1250	20,000	—	OCS-0820 #2 Blk 169 Ship Shoal Area
	48	dsl elec	2000	Emsco EDA	1250	20,000	—	OCS-0533 A-1 Blk 129 E Cameron Area
Zapata Off-Shore Co	Nola I	—	1500	130 Natl	—	15,000	—	Venezuela side, Gulf of Paria
	Nola III	—	2000	J-1250 Emsco	—	15,000	—	Trinidad side, Gulf of Paria

LAKE MICHIGAN

Global Marine Expl Co	Submarex Floating Vessel	dsl eng	150	Howard Turner	150	3,000	600+	—

LOUISIANA

Blue Water Drlg Corp	"Blue Water No 1"	dsl elec	2700	Emsco EDES	2600	20,000	67	Block 139, Ship Shoal Area
Circle Drlg Co Inc	Circle No 6 Bge Kirk C Lewis	dsl elec	3000	Ideco E-2500	3000	20,000	12	South Marsh Island State Lease 340
Coral Drlg Co	#1	dsl elec	3000	Brwstr N-12	3000	20,000	70	Bay-Marchand State lease 1424
Delta Marine Drlg Co	Joseph Zeppa Rig #1	dsl elec	2300	Emsco J-1250	1200	15,000	—	Plaquemines Blk #31
	Chris Zeppa Rig #2	dsl elec	2000	Ideco Big gnt	1200	15,000	34	Cameron
Dixilyn Drlg Corp	Rig #8 "Julie Ann"	dsl	2490	Natl 1625-DE	2490	25,000	105	Blk 77 So. Timbalier
Kerr-McGee Oil Ind Inc	44	dsl	2000	Ideco 1350-S	1700	18,000	—	State lease 1012 A-4 S Pass Blk 27 Field
Louisiana-Delta Offshore Corp	1	dsl	800	U-20	1000	14,000	—	St Mary
	2	dsl elec	1400	U-1220	1200	20,000	—	—
	3	dsl elec	2000	U-1220	1200	20,000	—	—
Movible Offshore Co	Movible No 2	dsl elec	2000	Natl 1625	2500	25,000	—	State Lse 691, Blk 119 Eugene Is. area
Nicklos Drlg Co	20	dsl eng	2250	Natl 130	2250	20,000	8	St Mary
	21	dsl eng	2250	Natl 130	2250	20,000	8	Iberia
	22	dsl eng	—	Natl 125	1400	17,000	50	Jefferson
Ocean Drlg & Expl Co	Mr Charlie	dsl elec	—	Emsco	—	15,000	40	So Pelto Blk 79
	John Howard	dsl elec	—	Emsco ECA	—	15,000	30	Eugene Is Blk 89
	St Louis	dsl elec	—	Emsco ECA	—	15,000	30	W Cameron Blk 19
	Margaret	dsl elec	—	Emsco EDES	—	15,000	65	South Pass Blk 27
	El Dorado	dsl elec	—	Emsco EDES	—	15,000	70	Eugene Is Blk 129-A
Penrod Drlg Co	Rig No 50 "W O Woodward"	dsl elec	3000	Emsco EDES	1800	20,000	44	Block 76 Eugene St Mary
	Rig No 51 "Jim Woodruff"	dsl elec	2000	Emsco EDES	1800	20,000	60	Bay Marchand Area LaFourche
	Rig No 52 "Petrel"	dsl elec	2000	Emsco EDES	1800	20,000	100	Eugene Island Area St Mary
Reading & Bates Expl Co	Clayton G Dorn	dsl	1800	"Oilwell" 96	1800	18,000	—	Black 215 Eugene Island Area
	"Mr Louie"	dsl elec	2000	M-CSCO U-1220	2000	20,000	110	Block 49 South Marsh Island Area
	Geo M Reading	dsl eng	2000	Natl 130	2000	18,000	—	Blk 23 So Marsh Is
Rimrock-Tidelands Inc	"Rimtide"	dsl	2000	Emsco A-1500	1500	20,000	36	W Delta Blk 27
	Union Prod Co Drill Barge A	dsl elec	1250	Ideco E-2500	1600	25,000	70	Eugene Is Blk 53
Salt Dome Prod Co	14	dsl	—	Natl 55	850	10,000	200	Morgan City
	15	dsl	2200	Natl 110	1500	16,000	136	Federal Block 134
Sea Drlg Corp	#2	dsl elec	1800	Natl	1800	18,000	30	Blk 16 E Cameron
	#3	dsl elec	1800	Emsco	1800	18,000	30	Blk 26 West Delta
Southeastern Drlg Co	22	dsl & dsl elec	2200	Natl 8.5 FE-34	2200	16,000	25	Ship Shoal Block 107
Tidelands Drlg Co	Mr Gus No 2	dsl elec	3600	Natl 160-E	1800	20,000	150	West Delta Blk 71
Zapata Off-Shore Co	Scorpion	—	2400	"Oilwell" 96	—	15,000	140	Blk 165 W Cameron

MEXICO

Zapata Off-Shore Co	Vinegaroon	—	2400	"Oilwell" 96	—	15,000	85	Santa Anna field

PERSIAN GULF

Reading & Bates Offshore	J W Bates	dsl eng	2000	Natl 130	2000	18,000	—	—
	O E Thornton	dsl eng	2000	Natl 130	1800	16,000	125	—

TEXAS

Continental Marine Expl Co	12	dsl eng	1875	Wlan Spr Titan 66	1875	22,800	35	State Tract 4755 Matagorda Co
Movible Offshore Co	Movible No 3	dsl elec	1700	Emsco EDA	1600	20,000	—	State Tract 216-S Galveston County

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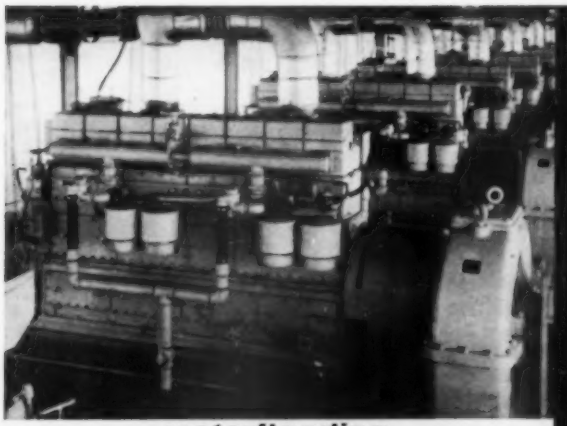

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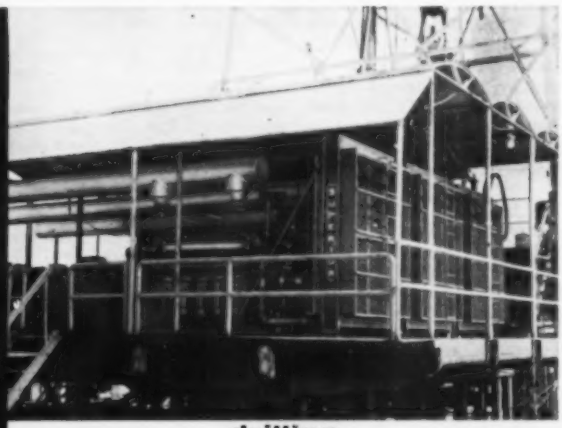

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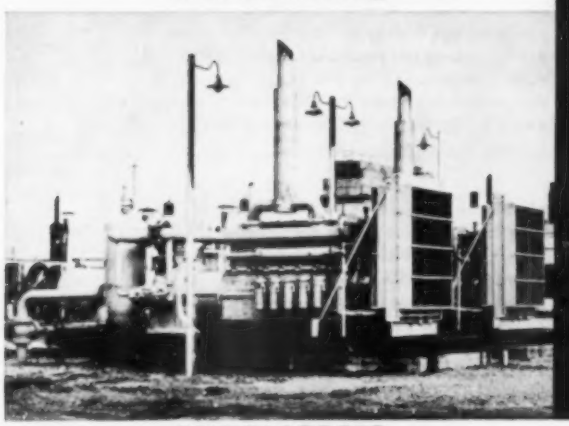

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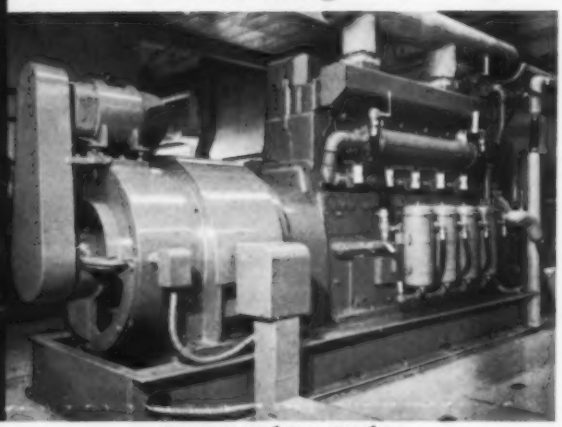

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B

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Baggett Drlg Co 4305 Univ Dr Wichita Falls Tex
Bar-Lee Drlg Co Box 7264 Tulsa Okla
Barker C H Box 91 Toronto Kans
Barry Well Drlg Co West Star Rt Fallon Nev
Beck K L 3826 Randolph Blvd San Antonio Tex
Bell & Gault Drlg Co 408 John R St Clare Mich
Bennett and Roberts Drlg Russell State Bank Bldg Russell Kans
Bernhardt Drlg Co 2469 Grand River Detroit 1 Mich
Bills Drlg Serv 617 Union Natl Bldg Wichita 2 Kans
Boyd Tom Drlg Co 102 S 2nd St Artesia N Mex
Brown & Thorp Drlg Co Box 1359 McCamey Tex

C

Canton Oil & Gas Co 626 Renkert Bldg 306 N Market Ave Canton 2 Ohio
Capitol Drlg & Serv Co 854 S Grant St Casper Wyo
Carter Drlg Co 1640 W 34th St N Wichita Kans
Casselman Bros Drlg Co Rt 1 Morris Okla
Crouch Louis Box 687 Lockhart Tex
Cullet Harry L Purefoy Hotel Talladega Ala
Cumberland Trucking & Drlg Co Inc Rt 1 Celina Tenn
Cummins Drlg Co Altamont Ill

D

Dillier W L Box 205 Casey Ill
Dobson Well Serv Box 282 McLeansboro Ill

E

Eatmon Drlg Co Box 535 Kimball Neb
Ensminger Drlg Co Box 45 Chanute Kans

F

Fair Oil Co Box 689 Tyler Tex
Fairman Drlg Co Hammersley Fork Pa
4-J Drlg & Well Serv Co Box 471 Drumright Okla

G

Gladson Willard & Odstrcil Bros Drg Co 2705 W 35th St Snyder Tex
Grandfield Drlg Co 1518 E 8th St Okmulgee Okla
Gross Drlg Co 1124 Douglas Rd Eldorado Kans
Gulf Coast Western Oil Co 1816 Republic Bldg Oklahoma City Okla

H

Hatcher H F & Son Drlg Co Box 447 Smackover Ark
Henderson Ed F Box 531 Monahans Tex
Highland Oil Box 263 Jasper Ind
Hipp Chas E Box 26 Graham Tex
Holdeman Oil & Minerals Inc 812 N W W White Rd San Antonio Tex
Holt Bros Drlg Co Box 236 Pampa Tex
Horn R L & Sons Drlg Co Pawnee Okla
Houchins Drlg Co Box 388 Mt Carmel Ill

J

Jameson Charles M 4171 S Broadway Englewood Colo
Jetmar Well Serv Box 736 Great Bend Kans
Johnson F M Well Serv Box 613 Olney Tex
Jones Bros Oil Co Sedan Kans
Jones Buck Drlg Co Box 1085 McCamey Tex
Jones Kenneth E Producer 528 S 94th 9th Ave Tulsa Okla

K

Kersey & Co Box 305 Artesia N Mex
Kimbark Expl Co 300 Fillmore Denver Colo
Kirby Oil Ind Inc 5107 Center St Omaha 6 Neb
Krumme Oil Co Box 749 Bristow Okla

L

Lawrence J W Box 942 Conrad Mont
Lindsay Drlg Co 1305 S Highland Chanute Kans
Lininger H J Box 37 Upper Sandusky O
Lin-Mour Drlg Co 1112 Oil & Gas Bldg Wichita Falls Tex
Lohmann-Johnson Drlg Co Inc 320 Indiana Bk Bldg Evansville Ind

M

McCabe Drlg Co Box 87 Cleveland Okla
McQueen & Stout Drlg Co 1113 Ft Worth Natl Bk Bldg Ft Worth 2 Tex
Morgan Dave Drlg Co Box 820 Blackwell Okla
Murphy & McKernan Box 169 Pampa Tex

N

Northern Drlg Co Kevin Mont

O

Oien Oil Corp Box 2235 Cut Bank Mont
Oilwell Service Co Box 2185 Cut Bank Mont
Oney Drlg Co Box 425 Graham Tex

P

Payne Bros Drlg Co 611½ 12th St Box 15 Lawrenceville Ill
Peters Drlg Co American State Bk Bldg Great Bend Kans
Pollard C C & Son Box 65 Ft Stockton Tex
Pool Fred Drlg Co 3106 Lockheed Midland Tex
Porter & Rooks Drlg Co Box 753 Rangely Colo
Prairie Drlg Co Box 2068 Casper Wyo
Prairie Oilfield Serv Inc Box 97 Great Bend Kans

R

Robinson Mrs Arthur D Kirby Bldg Dallas Tex
Robinson Bros Oil Producers Box 430 Borger Tex
Rudy J W Box 684 Clay City Ill
Russell & Russell Drlg Co 621 Lindsay St Gainesville Tex
RWIT Box 551 324 W Main St Holdenville Okla
R-Y Oil Co Inc Miami Okla

S

Sage Drlg Co Inc 800 Bitting Bldg Wichita 2 Kans
Shields Oil Producers Inc Box 709 Shields Bldg Russell Kans
Signal Oilfield Serv Inc 415 Petr Club Bldg Denver Colo
Slape Don Drlg Co Box 432 Olney Ill
Smith James Drlg Contr Box 33 Mertzon Tex
Smith K Cable Tools 1801 Van Buren Great Bend Kans
Smith Ray Drlg Co 305 Simons Bldg Dallas Tex
Story Jack L Box 1073 Dallas Tex
Stratman C W Drlg Co 620 S 30th St Mattoon Ill
Sutton Drlg Co Box 6446 San Antonio Tex
Swindler H L Box 1247 Muskogee Okla

T

Temple Drlg Co Inc 320 Indiana Bk Bldg Evansville Ind
TOCK Drlg Co 617 Union National Bldg Wichita Kans
Tolson Drlg Co 213 Triangle Bldg Pawhuska Okla
Turpin G H Drlg Co 306 Austin Borger Tex

V

V S & S Drlg Co 1004 Ridgley Bldg Springfield Ill
Varner A L & J N 550 E N 21 St Abilene Tex
Varner W H Drlg Co Box 1999 Abilene Tex
Virginia Drlg Co Inc 712 Brown Bldg Wichita 2 Kans

W

Wagner J H Drlg Co Box 751 Eldorado Kans
West Art Drlg Co 205 O'Michael Bldg Odessa Tex
Wright Drlg Co Box 348 Great Bend Kans

Y

Young W J 1511 Thompson Bldg Tulsa Okla

U. S. Contract CABLE TOOL Drilling Rigs

Contractor's Name	Rig No.	Type Power	HP of Driving Engine	Rated Drlg. Depth-Ft.	Rig Make & Model
		ALABAMA			
Hamilton County					
Harry L Cullet	3	gas-gaso-btne	250	7000	Special
	1	gas-gaso-btne	125	3000	Crdwll H
Talladega County					
Harry L Cullet	2	gas-gaso-btne	150	5000	Star Spddr
		ARKANSAS			
Ouachita County					
H F Hatcher & Son	—	gas-gaso	145	5000	Crdwll K
		COLORADO			
Rio Blanco County					
Porter & Rooks Drlg Co	1	—	110	3000	Star 83
	2	—	135	4000	B Erie 36-L
	3	—	170	6000	B Erie 48-L
	4	—	135	6000	Crdwll RL
Washington County					
Kimbark Exploration Co	2	gaso	140	7500	Crdwll RL
		ILLINOIS			
Christian County					
C W Strotman Drlg Co	4	gas	175	3500	Crdwll K
V S & S Drlg Co	1	gas	175	3500	Wichtex
Clark County					
Don Slape Drlg Co	1	btne	—	—	Crdwll K
Clay County					
Shulman Bros	1	gas-gaso	—	4000	Crdwll H
J W Rudy	3	btne	130	—	Crdwll K
C W Strotman Drlg Co	3	gas	145	3600	Crdwll H
V S & S Drlg Co	3	gas	—	3500	Cooper
Coles County					
C W Strotman Drlg Co	1	gas	145	3600	Crdwll H
Crawford County					
W L Dillier	1	gas	65	1500	B Erie 60-L
Effingham County					
Cummins Drlg Co	C-7	gas-gaso	45	1000	B Erie 22-W
Fayette County					
Cummins Drlg Co	C-1	gas-gaso	65	1500	B Erie 24-L
	C-2	gas-gaso	65	1500	B Erie 24-L
	C-3	gas-gaso	65	1500	B Erie 60-L
	C-4	gas-gaso	65	1500	B Erie 60-L
	C-5	gas-gaso	78	2500	B Erie 28-L
	C-6	gas-gaso	78	2500	B Erie 28-L
Hamilton County					
Dobson Well Serv	3	gas	135	3500	Wlsn Sr
	5	gas	135	3500	Wlsn Sr
	9	prop	162	4000	Wlsn Sr
	15	prop	85	4000	Wlsn Sr
	23	prop	85	4000	Wlsn Sr
	29	prop	140	7000	Wlsn Sr
Lawrence County					
Payne Bros Drlg Co	1	dsl	150	3000	B Erie 36-L
	2	dsl	150	3000	B Erie 36-L
White County					
Lohmann-Johnson Drlg Co Inc	2	btne	—	4500	Crdwll
		INDIANA			
Gibson County					
Highland Oil	1	dsl	—	2000	B Erie 24-L
	2	dsl	—	3000	B Erie 28-L
C W Strotman Drlg Co	2	gas	175	3500	B Erie 36-L
Vanderburgh County					
Payne Bros Drlg Co	3	dsl	150	3000	B Erie 36-L
		IOWA			
Dallas County					
Kirby Oil Ind Inc	—	gas-gaso	145	—	B Erie 28-L
	—	gas-gaso	145	—	Crdwll RL
		KANSAS			
Allen County					
Ensminger Drlg Co	1	dsl	55	1500	Star
Lindsay Drlg Co	3	prop	90	1500	B Erie 24-L Spddr
Barber County					
Wright Drlg Co	1	btne	GK-145	8000	Crdwll 423
	3	btne	GK-145	8000	Crdwll 667
Barton County					
Sage Drlg Co Inc	1	prop	120	4500	B Erie
Peters Drlg Co	674	Cummins	200	6500	Crdwll RL GMD
Virginia Drlg Co Inc	1	btne	150	4000	Unit rig
Butler County					
J H Wagner Drlg Co	3	gas-LPG	145	3500	B Erie 36-L
Chautauqua County					
Jones Bros Oil Co	—	prop	140	1650	Ft Wrth Spdr Jumbo D

Contractor's Name	Rig No.	Type Power	HP of Driving Engine	Rated Drlg. Depth-Ft.	Rig Make & Model
Cowley County					
J H Wagner Drlg Co	2	gas-LPG	145	3500	B Erie 36-L
Edwards County					
Peters Drlg Co	673	Waukesha	145	6500	Crdwll RL GMD
Ellis County					
Shields Oil Prod Inc	3	dsl	—	8000	B Erie 48-L
Signal Oilfield Serv	1	prop	150	6000	—
	7	prop	135	5000	—
K Smith Cable Tools	1	gas-prop	140	5000	Wlkr-Nr
Ford County					
TOCK Drlg Co	3	prop	145	8000	Wlkr-Nr C-34
Graham County					
Signal Oilfield Serv	9	dsl	145	6000	—
Harper County					
Gross Drlg Co	2	prop-btne	250	5000	Unit V-34
Harvey County					
Wright Drlg Co	4	btne	GK-145	8000	Crdwll 683
Kingman County					
Peters Drlg Co	241	Cummins	300	6500	Crdwll KL
Pickrell Drlg Co	1	dsl	500	6500	M-CSCO U-15
Levinworth County					
R L Horn & Sons Drlg & Prod	1	dsl	90	2500	72 Spdstr
Marion County					
Carter Drlg Co	1	btne	140	6000	Wlkr-Nr S-43
	2	btne	140	4000	Wlkr-Nr
Meade County					
Bennett & Roberts Drlg	3	dsl	500	8000	Emsco GA-500
Morton County					
TOCK Drlg Co	1	dsl	145	7500	Crdwll RL
Neosho County					
Lindsay Drlg Co	1	dsl	90	3200	Star Spddr 43
Rice County					
Wright Drlg Co	2	dsl	Buda 844	8000	Crdwll 528
Rooks County					
Bill's Drlg Serv	1	dsl	—	5000	Crdwll Dble Drum
Russell County					
Bennett & Roberts Drlg	1	dsl	250	6000	Emsco GB-250
Shields Oil Prod Inc	2	dsl	—	8000	Crdwll
Seward County					
Bennett & Roberts Drlg	2	dsl	250	6000	Emsco GA-250
Stafford County					
Jetmar Well Serv	1	prop	—	—	Mobile Cooper E-563
Prairie Oilfield Serv Inc	1	LPG	150	10,000	Crdwll "RL"
Stanton County					
TOCK Drlg Co	2	dsl	145	7500	Crdwll RL
Sumner County					
Pickrell Drlg Co	10	dsl	500	6500	Ideco H-40
Wilson County					
Lindsay Drlg Co	2	dsl	104	3200	Star Spddr 43
Woodson County					
C H Barker	1	prop	145	3000	Wlkr-Nr 32
		KENTUCKY			
Bennett Drlg Co	6	LPG	—	1750	B Erie 24-L
Christian County					
Cumberland Trkng & Drlg Co Inc	2	prop	185	1250	B Erie 22-W
Clinton County					
W & H Drlg Co	1	gas	—	2000	B Erie 60
Hardin County					
Cumberland Trkng & Drlg Co Inc	1	prop	230	2000	B Erie 60-L
Henderson County					
Shulman Bros	2	gas-gaso	—	4000	Crdwll H
Temple Drlg Co Inc	1	btne	—	1800	B Erie 24-L
		MICHIGAN			
Bernhardt Drlg Co	2	dsl-gas	—	6000	B Erie 36-L
Hillsdale County					
Bell & Gault Drlg Co	1	gas-btne	145	6000	Wlkr-Nr S-33
Jackson County					
Bell & Gault Drlg Co	3	gas-btne	200	7000	Wlkr-Nr S-46-A
	2	gas-btne	145	6000	Wlkr-Nr S-33
Macomb County					
Bernhardt Drlg Co	2	dsl-btne	175	6500	B Erie-36
St Clair County					
Bernhardt Drlg Co	1	btne	175	5000	B Erie-36
		MONTANA			
Oilwell Serv	4	—	145	4000	Crdwll Model "K"
Liberty County					
B & B Drlg Co	1	nat gas-prop or gaso	145	3500	B Erie 36-L

Contractor's Name	Rig No.	Type Power	HP of Driving Engine	Rated Drlg Depth-Ft.	Rig Make & Model
Pondera County					
Aikins Drlg Co	2	gas	225	7500	B Erie 48-L
Teton County					
J W Lawrence	1	gas-gaso	125	3500	Natl
	2	gas-gaso	175	5000	B Erie
Toole County					
Aikins Drlg Co	1	gas-btne	140	3500	B Erie 36-L
Northern Drlg Co	1	gas-gaso	125	5000	Wich 66
Oien Oil Corp	1	dsl	150	3000	B Erie 36-L
	2	gas-LPG	150	3000	B Erie 36-L
Oilwell Serv	3	gaso	160	4000	B Erie 36-L
		NEBRASKA			
Banner County					
Eatmon Drlg Co	2	prop	—	—	Crdwll RL
Kimbark Expl Co	1	gaso	140	7500	Crdwll RL
	2	—	140	7000	Crdwll RL
Cheyenne County					
Eatmon Drlg Co	1	prop	—	—	Crdwll RL
Kimbark Expl Co	1	—	145	7000	Crdwll RL
Kimball County					
Eatmon Drlg Co	3	prop	—	—	Wlkr-Nr
	4	prop	—	8000	Frnks 658
	5	prop	—	12,000	Wisn Winchmobile
		NEVADA			
Churchill County					
Barry Well Drlg	2	gaso	35	500	Custom Spddr
		NEW MEXICO			
Eddy County					
Tom Boyd Drlg Co Inc	1	btne	145	4500	B Erie 36-L
	2	btne	145	5000	Wich 61
	3	btne	145	5000	Wich 61
Kersey & Co	1	gas-gaso	185	5000	Natl 3
	2	gas-gaso	120	3000	Wich Spddr 55
	3	gas-gaso	120	4000	Wich Spddr 61
	4	gas-gaso	120	4000	Natl 3
Lea County					
Fred Pool Drlg Co	—	—	—	4000	Ft Wrth Spdr F-37
Art West Drlg Co	3	gas	145	—	Crdwll KL
		OHIO			
Portage County					
Canton Oil & Gas Co	S-3	gas-gaso-prop	140	4500	B Erie 36-L
	S-5	gas-gaso-prop	140	4500	Wlkr-Nr S-33
	S-6	gas-gaso-prop	140	4500	B Erie 36-L
Stark County					
Canton Oil & Gas Co	S-4	gas-gaso-prop	140	4500	Wlkr-Nr S-33
Trumbull County					
Canton Oil & Gas Co	S-7	dsl	175	5500	B Erie 36-L
Upper Sandusky County					
H J Lininger	1	gas-gaso	65	2500	Cyclone
	2	gas-gaso	50	2000	Sndrsn Cyclone
		OKLAHOMA			
Beaver County					
Turpin Drlg Co	2	gas-gaso-prop	225	9000	B Erie 48-L
Creek County					
Fair Oil Co	1	btne	145	4000	B Erie 36-L
	2	btne	64	2500	B Erie 28-L
4-J Drlg & Well Serv	1	gaso	145	4000	B Erie 36-L
	2	gaso	135	4000	Wlkr-Nr 25-A
Krumme Oil Co	1	LPG	145	3500	B Erie 36-L
	2	LPG	95	3500	B Erie 36-L
W J Young	1	LPG	100	4000	Natl 2
Hughes County					
RWIT Drlg Co	1	gas-LPG	145	3500	Brwstr N-3
	2	gaso-LPG	190	1000	Mayhew 1000
Kay County					
Dave Morgan Drlg Co	—	LPG-gas	145	—	Crdwll RL
Muskogee County					
Swindler Oil Corp	1	gas	150	3500	Wlkr-Nr 33-Spl
	2	gas	150	2000	B Erie 28-L
Nowata County					
Bennett Drlg Co	8	LPG	—	2750	B Erie 28-L
Okmulgee County					
M H Casselman & Sons	1	LPG	90	2000	Ft Wrth Super D
	2	LPG	145	4000	Wlkr-Nr C-34
Grandfield Drlg Co	1	gas	100	2500	Natl No 2
	1	gas	100	1200	Spudder
W J Young	2	LPG	100	4000	Natl 2
Osage County					
Bar-Lee Drlg Co	1	LPG	120	3000	Wlkr-Nr 532
Gross Drlg Co	1	dsl	250	5000	Unit V-34
	5	prop-btne	250	9000	Beth S-45
Kenneth Jones Drlg Co	1	gas	300	2500	B Erie 28-L
McCabe Drlg Co	1	btne	—	3500	B Erie 36-L
Tolson Drlg Co	1	LPG	145	4000	Wlkr-Nr S-33
W J Young	3	LPG	100	4000	Natl 3

Contractor's Name	Rig No.	Type Power	HP of Driving Engine	Rated Drlg Depth-Ft.	Rig Make & Model
Seminole County					
Gulf Coast Western Oil Co	1	btne-gas	145	5000	Wlkr-Nr C-34
Tulsa County					
Bennett Drlg Co	2	LPG	—	3500	Star 45
		PENNSYLVANIA			
Clearfield County					
Fairman Drlg Co	1	dsl	225	7500	B Erie Spddr 48-L
	2	dsl	225	7500	B Erie Spddr 48-L
	3	gas	225	7500	B Erie Spddr 48-L
	4	gas	225	7500	B Erie Spddr 48-L
	5	dsl	170	5000	B Erie Spddr 36-L
		TENNESSEE			
Clay County					
Cumberland Trkng & Drlg Co Inc	3	prop	230	2000	B Erie 24-L
	4	prop	230	2000	B Erie 24-L
		TEXAS			
Archer County					
Baggett Drlg Co	4	—	—	7000	Wlkr-Nr C-27
Bexar County					
K L Beck	1	btne-gaso	195	1250	Keystone 50
Holdeman Oil & Minerals Inc	1	gaso	150	3000	Angelo
	2	gaso	90	1500	Alamo Iron Wks
Brewster County					
C C Pollard & Son	2	dsl	150	6000	WCH 66 Spddr
Callahan County					
Roy Arrowood	2	btne	60	1500	—
A L Varner	1	gas	60	1000	B Erie 22-W
	2	btne	120	1500	Failing
Clay County					
Jack L Story	1	gas	290	500	Wisn Mogul
Cooke County					
Chas E Hipp Co	16	btne	145	4000	B Erie 36-L
Mrs Arthur D Robinson	1	btne	85	2000	Spddr-3 drum
Russell & Russell Drlg Co	1	gas-btne	450	4000	Wisn Mogul Trcr
Ector County					
Art West Drlg Co	5	gas	185	—	Crdwll RL
	6	gas	145	—	Crdwll RL
	9	gas	185	—	Wisn Giant
	10	dsl	125	—	Crdwll RL
McQueen & Stout Drlg Co	20	LPG	185	5000	Crdwll RL
	16	LPG	185	5000	Crdwll RL
	18	LPG	145	5000	Natl 3
Gonzales County					
Sutton Drlg Co Inc	7	dsl	225	5000	Ammco
Gray County					
Murphy & McKernan	1	gas-gaso	145	4500	B Erie 36-L
	2	gas-gaso	145	4500	B Erie 36-L
Hockley County					
Art West Drlg Co	7	gas	145	—	Crdwll RL
Hutchinson County					
Carter Drlg Co	4	btne	145	11,000	Crdwll RL
Holt Bros Drlg Co	1	dsl	150	4000	Wlkr-Nr S-33
Robinson Bros Oil Producers	1	gas	200	4500	B Erie 48-L
Irion County					
James Smith Drlg Contr	1	btne engine	145	3000	B Erie 36-L
	2	btne engine	76	1500	B Erie 24-L
La Salle County					
Sutton Drlg Co Inc	10	dsl	875	12,000	Beth S-55
Maverick County					
Sutton Drlg Co Inc	3	dsl	350	8200	Brwstr N-4
	4	dsl	875	10,500	Brwstr N-4
Mitchell County					
Willard Gladson & Odstrcil Bros Drlg Co	3	btne	—	4200	B Erie 28-L
Palo Pinto County					
Oney Drlg Co	5	LPG	222	5500	Wich 66
Pecos County					
Buck Jones Drlg Co	1	btne	—	4000	Wlkr-Nr S-33
	2	btne	—	2500	Wlkr-Nr S-32
Fred Pool Drlg Co	—	—	—	4500	Ft Wrth Spddr J37
Ray Smith Drlg Co	33	gas-LPG	145	4500	Wlkr-Nr S-33
	43	gas-LPG	145	4000	Wlkr-Nr S-43
Potter County					
Turpin Drlg Co	1	gas-gaso-prop	225	9000	B Erie 48-L
Reeves County					
Louis Crouch	1	btne	225	3000	B Erie 36
Ray Smith Drlg Co	32	gas-LPG	145	3500	Wlkr-Nr S-32
Scurry County					
Willard Gladson & Odstrcil Bros Drlg Co	1	btne	—	5500	B Erie 36-L
	2	btne	—	5500	B Erie 36-L
R-Y Oil Co Inc	1	btne	165	5000	B Erie 36-L

Contractor's Name	Rig No.	Type Power	HP of Driving Engine	Rated Drlg. Depth-Ft.	Rig Make & Model
Shackelford County					
W H Varner Drlg Co	1	gaso	100	1000	B Erie 22-W
Taylor County					
A L & J N Varner	1	gaso	50	1000	B Erie 22-W
	2	btne	100	1500	Failing HD-1500
Tom Green County					
Angelus Drlg Co	1	btne	100	2000	Ft Wrth Super H
Upton County					
Brown & Thorp Drlg Co	2	btne	200	3500	Ft Wrth F-37
	3	btne	150	2500	Ft Wrth "D"
	4	btne	150	2500	Ft Wrth "D"
	5	btne	200	5000	Wich 66
	6	btne	200	3500	Ft Wrth F-37
Buck Jones Drlg Co	3	btne	—	5000	Natl Machine
Ward County					
Ed F Henderson	1	gas	209	500	Wlkr-Nr S-33
	2	gas	160	3500	Wlkr-Nr S-43
	3	gas	145	5000	Wlkr-Nr S-33
C C Pollard & Son	1	gas	150	4000	WCH 61 Spddr
Art West Drlg Co	8	gas	145	—	Crdwll RL
Wichita County					
Baggett Drlg Co	1	—	145	—	Wlkr-Nr 37
	3	—	190	—	Wlkr-Nr C-27
Lin-Mour Drlg Co	2	gas	125	—	Wlkr-Nr C-34
	3	btne	100	5000	Wlkr-Nr C-33
Wilbarger County					
Baggett Drlg Co	2	—	145	—	Wlkr-Nr 34
Young County					
Chas E Hipp Co	17	btne	225	6000	B Erie 48-L
	15	btne	145	4000	B Erie 36-L
	14	btne	145	4000	B Erie 36-L
	12	btne	145	4000	B Erie 36-L
	11	btne	225	6000	B Erie 48-L
F M Johnson Well Serv	1	btne	130	—	Jhnsn 30 Spec
	2	btne	145	—	Clark 30
	3	btne	135	—	Clark 30
	4	btne	145	—	Clark 30 Spec
	5	btne	145	5000	Clark 30 Spec
Oney Drlg Co	2	LPG	145	4000	Wich 61
UTAH					
Uintah County					
Charles M Jameson	1	gas-gaso	—	3500	B Erie 36-L
WEST VIRGINIA					
Mingo County					
Allen Drlg Co	1	gas	140	5000	B Erie 36-L
	3	gas	128	3500	Natl No 2
Wyoming County					
Allen Drlg Co	2	gas	140	5000	B Erie 36-L
WYOMING					
Natrona County					
Capitol Drlg & Serv Co Inc	1	nat gas	145	3500	B Erie 36-L
	2	nat gas	90	2500	B Erie 28-L
Sublette County					
Capitol Drlg & Serv Co Inc	3	nat gas	77	2500	B Erie 28-L
Weston County					
Prairie Drlg Co Inc	1	gas	200	11,000	Crdwll

Canadian CABLE TOOL Drilling Rigs

Culver Drlg Co Ltd Box 92 Dunnville Ontario Canada

Contractor's Name	Rig No.	Type Power	HP of Driving Engine	Rated Drlg. Depth-Ft.	Rig Make & Model
Ontario Province					
Culver Drlg Co Ltd	1	dsl	80	2500-3500	B Erie 28-L
	2	dsl	80	1500-2000	B Erie 24-L
	3	dsl	80	1500-2000	B Erie 24-L

U. S. Well Servicing Contractors

A A A Well Serv Box 1254 Shreveport La
Adams Prod Serv 2 Monte Vista Dr Bakersfield Calif
Albright Well Serv Co Box 1192 Hobbs N Mex
Anderson Oilwell Serv Box 304 McPherson Kans
Ansco Swabbing Serv Sourlake Tex
Arrow Well Serv 107 River Oaks St San Angelo Tex
Atlas Well Serv Inc Box 387 Ft Morgan Colo

B & G Well Serv Box 526 Winfield Kans
B & H Well Serv Box 1475 Coahoma Tex
Baggett Drlg Co 4305 Univ Ave Wichita Falls Tex
Barnard Well Serv Box 617 Madison Kan
Basin Well Serv Inc 2411 Rankin Hwy Midland Tex
Bateman & Whitsitt Inc Box 1956 Hobbs N Mex
Bayou Well Works Inc Box 78 New Iberia La
Beall Well Serv Co Box 20044 Houston 25 Tex
Berry Dick Well Serv Box 732 Great Bend Kans
Billings M E Well Serv Inc 928 E 15th St Casper Wyo
Birdwell J W (Johnny) Well Serv Box 201 Kamay Tex
Bivin & Smoot Drg Co Box 147 Overton Tex
Black Gold Well Serv Box 1427 OCS Lafayette La
Booksh Well Serv Box 127 Grosse Tele La
Brad-Tex Drlg Co Inc Box 1911 Monahans Tex
Brake Raymond K Well Serv Box 285 Centralia Ill
Brockett C H Inc Box 1005 Midland Tex
Browning Well Serv Inc Box 163 McLeansboro Ill

California Prod Serv Inc 3252 Cherry Ave Long Beach 7 Calif
Camden Drlg Co Box 1418 Corpus Christi Tex
Capshaw Well Serv Co Box 1915 Casper Wyo
Carpenter R L Box 452 Sapulpa Okla
Carlton Well Serv Box 91 South Houston Tex
Carter Well Serv Box 178 Pettus Tex
Carter-Jones Drlg Co Inc Box 1597 Kilgore Tex
Christian Inc 712 Commerce Exchange Bldg Oklahoma City 2 Okla
Christian, Sarratt & Wallace Ltd 712 Commerce Exchange Bldg Oklahoma City 2 Okla
Chris Well Serv Co Ltd 712 Commerce Exchange Bldg Oklahoma City 2 Okla
Clark Well Serv Co Box 4752 Oklahoma City 9 Okla
Clarke & Dennis Well Serv Inc Box 5 Medicine Lodge Kans
Clarke Oil Well Serv Co Box 2315 Hobbs N Mex
Cleaveland Well Serv Box 308 Luling Tex
Clinch Drlg Co Box 27 Hazlehurst Miss
Colo Well Serv Inc Box 122 Rangely Colo
Copeland & Fuller Well Serv Box 237 Kenedy Tex
Craig Well Serv Box 1796 Hobbs N Mex
Crusader Drlg & Serv Inc Box 851 Springhill La

D & R Well Serv Box 252 Edmond Okla
D & S Well Serv Co Box 102 Cody Wyo
Dawson Well Serv Box 72 Charlotte Tex
Dicks Well Serv Co Rt 2 Powell Wyo
Doe Robert B — Oilfield Serv Rt 1—19030 James Rd Bakersfield Calif
Drilling & Production Co 2907 L St Bakersfield Calif

Edwards Well Serv Box 415 Velma Okla
Eichler Well Service Box 515 Jacksboro Tex

Finley Oilwell Serv Inc Box 7296 Long Beach Calif
Flint Rig Co Box 342 Kimball Neb
Forsan Oil Well Serv Box A-584 Forsan Tex

Galloway Bros Continental Bk Bldg Ft Worth Tex
George Charles J Inc Box 1089 Odessa Tex
Gillespie Glenn & Sons Box 907 Cushing Okla
Goswick Leon & Co Box 167 Sweetwater Tex
Graham J P Box 1307 Bay City Tex
Gwaltney Henry Drlg Co Box 289 Washington Ind

Ham Carl S Inc Box 1058 Andrews Tex
Harrison Well Serv Box 21 Denver City Tex
Haseman John Inc 419 Wilson Bldg Corpus Christi Tex
Hayden & Griffith Oil Well Serv Co 304 Calif Bldg Denver 2 Colo
Hillier J E Box 67 Pleasanton Tex
Holston Well Serv Inc Box 651 Jennings La
Holt Ivan Well Serv Box 401 Russell Kans

Ideal Casing Co Box 746 Wink Tex
Iraan Oil Well Serv & Constr Co Iraan Tex

J & M Oil Well Serv Inc Box 1716—Oil Ctr Sta Lafayette La
J & M Well Serv Box 445 Mission Tex
Jackson Neil & Sons Star Rt East Artesia N Mex
Jetmar Well Serv Box 736 Great Bend Kans
Johnson F M Well Serv Box 613 Olney Tex
Lloyd Jones Drlg Co Box 491 Electra Tex

Kemp Drlg Co Box 748 Cushing Okla
Kinsey & Ham Inc 2004 N C St Midland Tex

L & W Well Serv MRH Box 120 Sulphur La
Lininger Oil & Gas Co Box 37 Upper Sandusky Ohio
Locke Well Serv Box 312 Royalty Tex
Lohmann Oil Well Serv Inc Box 1504 Farmington N M
Longhorn Serv & Drlg Co Box 427 Wink Tex

Macrate Prod Co 3341 Cherry Ave Long Beach 7 Calif
Maddox Prod Co 2909 Junipero Ave Long Beach 6 Calif
Marine Well Serv Co Box 1 Marine Ill
Maxwell Well Serv Co Box 475 New London Tex
McAdams J F Box 1716 Hobbs N M
McAlister Well Serv Box 2214 Wichita Falls Tex
McCutchin Gene Well Serv 1401 Mercantile Securities Bldg Dallas Tex
McDaniel Well Serv Box 456 Seminole Okla
McDonald Well Serv Co Box 2062 Abilene Tex
Mercer Jack Well Serv Box 509 Nocona Tex
Mobile Well Serv Box 36 Cayuga Tex
Moore Petroleum Serv Box 205 Missouri City Tex
Moore Prod Serv 1843 East -O- St Wilmington Calif

Nichols & Freeman Well Serv Box 183 Grandfalls Tex

Oien Oil Corp Box 2235 Cut Bank Mont
Oilwell Serv & Engr Inc Box 1567 Kermit Tex
Oil Well Serv Co 2405 Orange Ave Long Beach 6 Calif
Oliver Oil Well Serv 200 Berkley Ave Evansville Ind
O'Loughlin Well Serv Co Box 93 Perry Okla

Payne Bros Drlg Co Box 15 Lawrenceville Ill
Penick Dean Casing Pulling Box 5174 Midland Tex
Perkins J E Inc Box 3143 Odessa Tex
Permian Well Serv Inc Box 37 Wink Tex
Pool Well Serv Co Box 1940 San Angelo Tex
Potter W R (John) Well Serv Box 14 Kamay Tex
Prairie Drlg Co Box 2068 Casper Wyo
Price-Caudle Well Serv Inc Box 453 Seminole Okla
Producers Well Serv Inc Box 98 Boling Tex

Quad Drlg Co Box 974 Ardmore Okla

Ramey Well Serv 401-P Robertson Bldg Wichita Falls Tex
Rocket Well Serv Inc Box 1107 Glendive Mont
Rogers Ed Oil Well Serv Box 206 Holyrood Kans
Rush Well Serv Box 521 Lyons Kans

Sadie Workover Inc Box 877 Jena La
Savely Workover & Drlg Inc Box 407 Rosenberg Tex
Seaboard Well Serv Inc Box 1589 Lafayette La
Seale Well Serv 306 W Wharton Electra Tex
Seifried Well Serv 117 S Wyandotte Dewey Okla
Shirer Well Serv Co Box 118 Hoisington Kans
Shreve Pipe & Supply Inc Box 7023 354 Areo Dr Shreveport La
Simpson Wm G Well Serv Box 462 Robinson Ill
Smallwood Drlg Co 3657 E Kiest Blvd Box 9365 Dallas Tex
Smith John W Well Serv Box 323 Lockport La
Spartan Well Serv 207 S-T Bldg Corpus Christi Tex
Spears Well Serv Inc Box 3187 Victoria Tex
Stafford Well Serv Box 147 Linch Wyo
Steltle Drlg Co 1312 Southwood Dr Alice Tex
Stewart's Casing Crew Box 14086 Houston 21 Tex
Sunnyland Contracting Co Inc Box 388 Rayne La

T & H Well Serv Co Box 524 Eunice La
Taylor Dudley Elrod 118 Fifth Ave SE Cut Bank Mont
Texas Well Serv Co Box 191 Borger Tex
Todd J R Co Inc Box 168 Odessa Tex

Universal Oilwell Serv Inc Box 1092 Snyder Tex

Van Norman Oil Well Serv Inc Box 423 Edgerton Wyo
Virgil Well Serv Virgil Kans

W & C Well Serv 306 E Florida St Delhi La
W M & W Well Serv Co Box 931 Alice Tex
Wagner J H Drlg Co Box 751 Eldorado Kans
Weeks Well Serv Box 367 Susank Kans
Western Oil Well Serv Co Box 345 Glendive Mont
White Well Serv Box 356 Monahans Tex
Williamson Well Serv Inc Box 3828 Odessa Tex
Winnsboro Well Serv Co Box 102 Winnsboro Tex
Wood Sam E Box 546 Alvin Tex

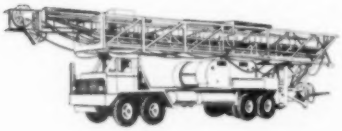
U. S. Contract Well Servicing or Pulling Units

Contractor's Name	Rig No.	Make & Model No. of Unit	How Unit is Transported	No. of Drums	Estimated Capacity Swabbing	Estimated Capacity Pulling	Can Unit Also Drill?
Maxwell Well Serv Co	1	Wlsn Spr	Truck	1	—	10,000/2" 8,500/2½" 6,500/3"	No
	2	Wlsn Spr	Truck	1	—	10,000/2" 8,500/2½" 6,500/3"	No
	3	Wlsn Spr	Truck	1	—	10,000/2" 8,500/2½" 6,500/3"	Yes
	4	Wlsn Spr	Truck	1	—	10,000/2" 8,500/2½" 6,500/3"	
	5	Wlsn Spr	Truck	1	9,500	—	—
Moore Prod Serv	1	Crdwll	Trailer	2	6,000	8,000/2" 6,000/2½" 5,000/3"	Yes
	2	Hopper Hoist	Truck	2	10,000	10,000/2" 10,000/2½" 9,000/3"	Yes
CALIFORNIA							
Bakersfield							
Adams Prod Serv	1	Wlsn Spr	Trailer	2	10,000	12,000/2" 9,000/2½" 6,000/3"	Yes
Calif Prod Serv Inc	M-21	Hopper	Hoistmobile	2	8,000	8,000	No
	M-22	Hopper	Hoistmobile	2	10,000	10,000	No
Robt B Doe Oilfield Serv	1	Crdwll H	Truck	1	4,500	5,000/2" 4,000/2½" 3,000/3"	No
	2	Crdwll HL	Truck	2	5,500	6,000/2" 5,000/2½" 4,000/3"	No
	3	Hopper	Truck	1	3,000	3,000/2" 2,000/2½" 1,500/3"	No
	4	Hopper	Truck	1	4,000	4,500/2" 3,500/2½" 2,500/3"	No
	5	Hopper	Truck	1	2,500	2,500/2" 1,500/2½" 1,000/3"	No
	6	Hopper IGFA	Truck	2	7,000	7,000/2" 6,000/2½" 5,000/3"	No
	7	Hopper IGFA	Truck	2	9,000	7,000/2" 6,000/2½" 5,000/3"	No
Drilling & Production Co	2	Crdwll	Trailer	2	15,000	14,000/2½"	Yes
	3	Ideco	Trailer	2	10,000	6,000/2½"	No
Oil Well Serv Co	1-A	Ideco 40	Trailer	2	13,000	13,000/2½" 10,000/3"	Yes
	2-A	Ideco 40	Trailer	2	13,000	13,000/2½" 10,000/3"	Yes
	11	Ideco 30	Trailer	2	10,000	10,000/2½" 8,000/3"	Yes
	12	Crdwll	Trailer	2	5,000	5,000/2½" 4,000/3"	—
	15	Ideco 30	Trailer	2	13,000	13,000/2½" 8,000/3"	Yes
	57	Ideco 35	Self-prop	2	13,000	13,000/2½" 8,000/3"	Yes
Gastaic							
Calif Prod Serv Inc	D-1	Hopper MTA	Trailer	2	15,000	15,000	Yes
	D-6	Emsco 500	Truck	2	15,000	15,000	Yes
	H-3	Hopper G	Truck	2	10,000	10,000	Yes
	H-10	Wgnr Mrhse	Truck	2	10,000	10,000	Yes
	M-7	Hopper	Hoistmobile	2	8,000	8,000	No
	M-13	Hopper	Hoistmobile	2	10,000	10,000	No
Kerman							
Oil Well Serv Co	41	Ideco 30	Trailer	2	10,000	10,000/2½" 7,000/3"	—
	60	Ideco H-25 CD	Self-prop	2	11,500	10,000	Yes
	A-4	Ideco 30	Trailer	2	10,000	10,000/2½" 7,000/3"	Yes
Long Beach							
Calif Prod Serv Inc	H-1	Crdwll "R"	Truck	2	10,000	10,000	Yes

The Man Who . . .

PULLS OIL WELLS OUT OF TROUBLE.

When you're in trouble you look for a friend that you can depend on . . . just as oil men depend on servicing contractors to keep their wells pumping at top efficiency. And, experience teaches that the most dependable contractor is the one with **good equipment . . .** like Franks . . . equipment engineered and built to keep the contractor as well as the producer out of trouble. **So, next time you are faced with servicing problems, look for** **proven dependability. Ask the man who uses Franks . . .** about the equipment that keeps him out of trouble.



WELL SERVICING AND DRILLING UNITS

FRANKS

PAMPA, TEXAS

CABOT

CABOT CORPORATION
MACHINERY DIVISION

Contractor's Name	Rig No.	Make & Model No. of Unit	How Unit is Transported	No. of Drums	Estimated Capacity Swabbing	Pulling	Can Unit Also Drill?
	H-5	Hopper G	Truck	2	10,000	10,000	Yes
	M-2	Hopper G	Trailer	2	10,000	10,000	Yes
	M-4	Hopper G	Trailer	2	10,000	10,000	Yes
	M-5	Ideco H-30	Trailer	2	10,000	10,000	Yes
	M-8	Wgnr Mrhse	Trailer	2	10,000	10,000	Yes
	M-14	Hopper	Hoistmobile	2	10,000	10,000	No
Finley Oilwell Serv Inc	1	Bender Guyless	Truck	2	12,000	10,000/2" 8,000/2½" 6,000/3"	Yes
	2	Bender Guyless	Truck	2	10,000	8,000/2" 6,000/2½" 4,000/3"	Yes
Macrate Prod Co	1	Ideco H-30	Trailer	2	10,000	12,000/2" 10,000/2½" 8,000/3"	Yes
	4	Wgnr Mrhse	Trailer	2	10,000	12,000/2" 10,000/2½" 8,000/3"	No
	6	Wgnr Mrhse	Trailer	2	10,000	12,000/2" 10,000/2½" 8,000/3"	No
	8	Wgnr Mrhse	Trailer	2	12,000	14,000/2" 12,000/2½" 10,000/3"	Yes
Maddox Prod Co	1	Hopper	Truck	2	8,000	12,000/2" 9,000/2½" 7,000/3"	Yes
	2	Wisn Spr	Trailer	2	10,000	17,000/2" 13,000/2½" 10,000/3"	Yes
	3	Ideco H-30	Truck	2	8,000	13,000/2" 10,000/2½" 8,000/3"	Yes
	4	Wisn Mogul	Trailer	2	13,000	17,000/2" 13,000/2½" 10,000/3"	Yes
Oil Well Serv Co	2	Wisn Mogul	Truck	1	—	12,000/2½" 6,500/3"	Yes
	3	Ideco	Truck	2	13,000	13,000/2½" 7,000/3"	Yes
	5	Ideco	Truck	2	5,000	5,000/2½" 4,000/3"	Yes
	6	Crdwll	Truck	2	10,000	7,000/2½" 6,500/3"	—
	7	Ideco 30	Trailer	2	13,000	13,000/2½" 7,000/3"	Yes
	8	Ideco H-25 AD	Truck	2	11,500	10,000	Yes
	9	Ideco 30	Trailer	2	13,000	13,000/2½" 7,000/3"	Yes
	10	Hydrair	Tractor	2	—	—	—
	14	Ideco 30	Trailer	2	13,000	13,000/2½" 7,000/3"	Yes
Ventura							
Calif Prod Serv Inc	D-2	Hopper MTA	Trailer	2	15,000	15,000	Yes
	D-3	Hopper MTA	Trailer	2	15,000	15,000	Yes
	D-4	Hopper MTA	Trailer	2	15,000	15,000	Yes
	D-5	"Oilwell" 66	Truck	2	15,000	15,000	Yes
	M-9	Hopper	Hoistmobile	2	10,000	10,000	No
	M-10	Hopper	Hoistmobile	2	10,000	10,000	No
		COLORADO					
Ft Morgan							
Atlas Well Serv Inc	1	Frnks Rocket	Truck	2	8,000/1⅛"	10,000/2"	No
	2	Frnks Explr	Truck	1	—	10,000/2"	No
	3	Frnks Explr	Truck	2	8,000/1⅛"	10,000/2"	No
	4	Frnks Rocket	Truck	2	8,000/1⅛"	10,000/2"	Yes
Rangely							
Colo Well Serv Inc	2	Frnks	Truck	2	—	—	—
	3	Frnks	Trailer	2	12,000	12,000/2"	Yes
	4	Frnks	Truck	2	12,000	12,000/2"	—
	5	Frnks	Truck	2	—	—	—
Sterling							
Flint Rig Co	81	Cooper	Truck	2	8,000	12,000	Yes
Hayden & Griffith Oil Well Serv Co Inc	201	Frnks 658 DTD	Truck	—	10,000	14,000/2"	Yes
	205	Frnks 658	Truck	—	10,000	14,000/2"	Yes
		ILLINOIS					
Centralia							
Raymond K Brake Well Serv	2	Cooper	Truck	1	3,000	3,500/2½"	No
	3	Wisn Jr	Truck	1	1,500	1,600/2½"	No
	4	Cooper W-226	Truck	2	3,000	3,500/2½"	Yes
	5	Wisn Sup	Truck	2	5,000	5,000/2½"	Yes
	7	Wisn Sup	Truck	1	5,000	5,000/2½"	No
Browning Well Serv Inc	258	Wichtex	Truck	1	—	4,500	No

Contractor's Name	Rig No.	Make & Model No. of Unit	How Unit is Transported	No. of Drums	Estimated Capacity Swabbing	Pulling	Can Unit Also Drill?
Lawrenceville							
Payne Bros Drlg Co	4	Crdwll	Skid	2	2,500	2,500	Yes
Marine							
Marine Well Serv	1	Fred Cooper	Truck	1	—	3,500/2½"	No
McLeansboro							
Browning Well Serv Inc	244	Wichtex C-60 Double drum	Truck	2	4,000	4,500	No
	246	Wisn	Truck	1	—	4,000	No
	259	Crdwll Q	Truck	1	—	4,000	No
Robinson							
Wm G Simpson Well Serv	4	Wisn Sr	Truck	2	4,000	3,500	Yes
	5	Wisn Jr	Truck	2	2,500	2,900	Yes
	6	Wisn Jr	Truck	2	2,500	2,500	Yes
	7	Wisn Sr	Truck	2	4,000	3,500	Yes
Taylorville							
Raymond K Brake Well Serv	1	Vicers	Truck	1	3,000	3,500/2½"	No
	6	Cooper G-226	Truck	3	4,000	4,000/2½"	Yes
		INDIANA					
Evansville							
Oliver Oil well Serv	2	Crdwll Q	Truck	1	—	3,500	No
Washington							
Gwaltney Drlg Inc	1	Wisn Spr	Truck	1	4,000	4,000	No
	2	Crdwll Q	Truck	1	4,000	4,000	No
	3	Daney M	Truck	2	1,500	1,500	Yes
	4	Cooper	Skid	3	6,000	6,000	Yes
		KANSAS					
Cowley							
J H Wagner Drlg Co	3	B Erie 36-L	Skid	3	4,500	4,500	Yes
Ellsworth							
Ed Rodgers Oil Well Serv	1	Crdwll HSKBS	Truck	1	5,000	5,000/2"	No
	2	Cooper E-563	Truck	1	5,000	5,000/2"	No
Eureka							
Virgil Well Serv	4	Cooper WD	Truck	1	—	3,500	No
Great Bend							
Dick Berry Well Serv	1	Crdwll HS-850	Truck	1	—	6,000/2" 5,500/2½" 4,500/3"	No
Jetmar Well Serv	1	Cooper E-563	Truck	2	7,000	10,000/2" 8,500/2½" 7,000/3"	Yes
Hoisington							
Shirer Well Serv Co	1	H Crdwll	Truck	1	—	—	No
	2	Frnks	Truck	1	—	—	No
	3	Crdwll H	Truck	2	—	—	No
Lyons							
Rush Well Serv	—	Cooper 53	Truck	—	3,200	3,200/2"	No
	—	Cooper 51	Truck	—	3,200	3,200/2"	No
	—	Crdwll	Truck	—	3,200	3,200/2"	No
Madison							
Barnard Well Serv	7	Cooper mdl W	Truck	1	—	3,000	No
	9	Cooper mdl W	Truck	1	—	3,000	No
	12	Cooper mdl W	Truck	2	3,000	3,000	Yes
	13	Cooper mdl W	Truck	1	—	3,000	No
	14	Cooper mdl W	Truck	1	—	3,000	No
	16	Cooper mdl W	Truck	2	3,000	3,000	Yes
McPherson							
Anderson Oilwell Serv	1	Crdwll HS	Truck	1	4,500	4,000	No
	2	Crdwll HS	Truck	1	4,500	4,000	No
Medicine Lodge							
Clarke & Dennis Well Serv Inc	14	Crdwll AH	Truck	2	6,000	5,500	No
	15	Frnks	Truck	1	8,000	7,000	No
	16	Frnks	Truck	2	8,000	7,000	Yes
Russell							
Ivan Holt Well Serv	1	SRKR-6	Truck	1	—	8,000/3½"	No
	2	MZR	Truck	1	—	6,500/2½"	No
	3	SRKR-6	Truck	1	—	8,000/2½"	No
	4	Frnks 44 DTM	Truck	2	—	6,500/2½"	No
Moundridge							
Rush Well Serv	—	Crdwll	Truck	—	3,200	3,200/2"	No
Swank							
Weeks Well Serv	1	Crdwll H	Truck	1	—	4,000/3"	No
	2	Crdwll H	Truck	1	—	4,000/3"	No
	3	Crdwll H	Truck	2	5,000	4,000/3"	No
Winfield							
B & G Well Serv	52	Crdwll	Truck	1	—	5,000	No
	94	Crdwll	Truck	1	—	5,000	No
	107	Crdwll Double	Truck	2	4,000	5,000	No
	114	Cooper double drum	Truck	2	4,000	5,000	No
	125	Crdwll triple drum	Trailer	3	5,000	6,000	Yes
		LOUISIANA					
Buras							
Clinch Drlg Co	1	Emsco 350	Inland Bge	2	10,000	15,000	Yes

Contractor's Name	Rig No.	Make & Model No. of Unit	How Unit is Transported	No. of Drums	Estimated Capacity Swabbing	Estimated Capacity Pulling	Can Unit Also Drill?
Delhi							
W & C Well Serv	1	Wichtex HD C-60	Truck	2	6,500	5,000/2½" 6,000/2" 4,000/3"	Yes
	2	Wichtex HD C-60	Truck	2	6,500	5,000/2½" 6,000/2" 4,000/3"	Yes
	3	Wichtex HD C-60	Truck	2	6,500	5,000/2½" 6,000/2" 4,000/3"	Yes
	4	Wisn Spr 38-D	Truck	2	12,000	9,000/2½" 10,000/2" 8,000/3"	Yes
Empire							
Bayou Well Works Inc	Bge 1	Wisn	Bge skid	1	14,000	—	No
Eunice							
T & H Well Serv Co	1	Wisn Spr 38	Trailer	1	—	W O Pulling	Yes
	3	Wisn Spr	Truck	1	—	10,000/2" 8,000/2½"	No
	5	Wisn Spr	Truck	1	—	10,000/2" 8,000/2½"	No
	16	Wisn Spr	Truck	1	12,000	—	No
	18	Wisn Spr	Truck	1	—	10,000/2" 8,000/2½"	No
	20	Wisn Spr	Truck	1	—	10,000/2" 8,000/2½"	No
	25	Wisn Spr	Truck	1	12,000	—	No
	30	Wisn Spr	Truck	1	—	10,000/2" 8,000/2½"	No
	39	Wisn Spr 38	Truck	1	10,000	—	No
	40	Wisn Spr	Truck	1	12,300	—	No
	51	Wisn Spr 38	Truck	1	—	10,000/2½"	Yes
Grosse Tete							
Booksh Well Serv	1	Cooper Skytop	Truck	—	—	12,000/2"	No
	2	Cooper Skytop	Truck	—	—	12,000/2"	No
	3	Cooper Swab	Truck	—	14,000	—	—
	4	Frnks 96' Mst	Trailer	—	—	16,000/2"	Yes
Jena							
Sadie Workover Inc	1	Wisn Spr 38	Truck	1	—	10,000/2½"	Yes
	2	Unit Rig U-34-D	Trailer	2	12,000	16,000/2½"	Yes
	3	Wisn Mogul 42	Truck	1	10,000	—	No
	4	Wisn Spr	Truck	1	—	4,000/2½"	No
Jennings							
Holston Well Serv Inc	1	Wisn Spr	Truck	—	13,000	—	No
	2	Wisn Spr	Truck	1	—	10,000/2"	No
	3	Wisn Spr	Truck	—	13,000	—	No
	4	Wisn Spr	Truck	—	—	10,000/2"	No
	5	Wisn Spr 38	Truck	—	—	10,000/2"	No
	6	Wisn Spr 38	Truck	—	—	13,000/2"	No
	7	Wisn Spr 38	Truck	—	—	13,000/2"	Yes
	8	Wisn Mogul 42 Winchmobile	Self-prop	—	—	16,000/2½"	Yes
	9	Wisn Spr 38 Winchmobile	Self-prop	—	—	13,000/2"	No
Lafayette							
Black Gold Well Serv	1	Crdwll H	Skid Mtd	1	Concentric Tubing		No
	3	Crdwll L	Skid Mtd	1	Concentric Tubing		No
J & M Oil Well Serv Inc	1	Wisn Giant	Skid	1	12,000	12,000/2½"	Yes
	2	Wisn Giant	Skid	1	—	17,000/2½"	Yes
Seaboard Well Serv Inc	1	Crdwll mdl-S	Truck	1	—	14,000/2½"	No
Lockfort							
John W Smith Well Serv	2	Frnks 658	Self-prop	1	—	14,000/2½"	Yes
New Iberia							
Bayou Well Works Inc	51	Wisn	Truck	1	12,000	—	No
	58	Brwstr	Truck	1	15,000	—	No
	63	Wisn Spr	Truck	1	12,500	—	No
	70	Wisn Spr	Truck	1	12,500	—	No
	107	Frnks	Truck	1	12,500	—	No
Plaquemine							
Clinch Drlg Co	1	Emsco 350	Barge		12,000	16,000	Yes
Rayne							
Sunnyland Contr Co Inc	8	Cardwell D	Trailer	1	10,000	13,000	Yes
Shreveport							
AAA Well Service Co	1	Fred Cooper	Truck	1		9,000	No
	2	Cooper 32	Truck	1	9,000	—	No
	3	Wisn Spr	Truck	2	6,500	5,000/2"	No
	4	Wisn Sr.	Truck	2	6,500	4,500	No
Shreve Pike & Supply Inc	1	Wisn Sup	Trailer	1	—	—	Yes
	2	Wisn Sup	Sub Str	1	—	—	Yes
Springhill							
Crusader Drlg & Serv Inc	4	Wisn Spr	Truck	1	—	6,500/2½"	Yes
	5	Wisn Spr	Truck	2	10,000	6,500/2½"	Yes
	7	Wisn Spr	Truck	1	10,000	—	No
	11	Wisn Spr 38	Truck	1	—	10,000/2½"	Yes
	13	Wisn Spr	Truck	1		6,500/2½"	Yes
Sulphur							
L & W Well Serv	3	Cooper L-190	Truck	—	—	10,000/2"	Yes
	5	Cooper TC4210	Self-prop	1	—	10,000/2"	Yes
MISSISSIPPI							
McComb							
W & C Well Serv	5	Wisn Spr 38	Trailer	2	12,000	9,000/2½" 10,000/2" 8,000/3"	Yes
	6	Wisn Mogul 42 winch mobile	Self-prop	1	15,000	16,000/2½" 16,000/2" 10,000/3	Yes
	7	Wisn Spr 38	Truck	1	12,000	9,000/2½" 10,000/2" 8,000/3"	No
	8	Brwstr 170W	Skid	1	16,000	—	No
MONTANA							
Cut Bank							
Dudley Elrod Taylor	1	Western Gnt Spr	Truck	2	4,000 4,000 8,000	4,000/2½"	Yes
	3	Crdwll AH	Truck	2	7,000	5,000/2½"	No
	4	Frnks 26	Truck	1	—	3,200/2½"	No
	5	Frnks RD-190	Truck	1	14,000 9/16"	10,000/2½"	No
Glendive							
Rocket Well Serv	1	Frnks Rocket	Truck	2	12,000	12,000/2"	Yes
	5	Frnks Rocket	Truck	2	12,000	12,000/2"	Yes
	4	Frnks Expl	Truck	2	12,000	12,000/2"	Yes
Western Oil Well Serv Co	1	Wisn Torcair	Truck	—	14,000	14,000	Yes
	2	Wisn Spr 38	Truck	—	12,000	12,000	No
	3	Wisn Mogul	Truck	—	12,000	12,000	No
Oilmont							
Olen Oil Corp	1	B Erie 36-L	Trailer	3	4,000	4,000	Yes
	2	B Erie 36-L	Trailer	3	4,000	4,000	Yes
	4	Beth S-50	Skid	1	3,500	4,000	Yes
Poplar							
Western Oil Well Serv Co	4	Wisn Spr 38	Truck	—	12,000	12,000	Yes
Roundup							
Olen Oil Corp	3	Natl T-20	Skid	1	7,000	10,000	Yes
Toole							
Olen Oil Corp	4	Beth S-50	Skid	1	9,000	8,000	Yes
NEBRASKA							
Kimball							
Flint Rig Co	23	Frnks 658	Truck	2	7,000	12,000	Yes
	57	Frnks 658	Truck	2	8,000	12,000	Yes
	160	Derrick Hopper		2	8,000	14,000	
	309	Frnks	Truck	1	—	10,000	Yes
Hayden & Griffith Oil Well Serv Co Inc	203	Frnks 658 DTD	Truck	—	10,000	14,000/2"	Yes
	204	Frnks 658 DTD	Truck	—	10,000	14,000½"	Yes
NEW MEXICO							
Artesia							
Neil Jackson & Sons	1	Wisn	Truck	1	4,000	—	No
	2	Crdwll	Truck	2	3,500	3,500/2" 3,000/2½" 2,500/3"	No
	3	Wisn Spr	Truck	2	6,000	6,000/2" 5,000/2½" 4,000/3"	No
	4	Frnks 658-137	Truck	2	12,000	12,000/2½"	No
Eunice							
Clarke Oil Well Serv Co	4	Frnks 658	Truck	2	13,500	13,500/2"	No
	5	Frnks 658	Truck	2	13,500	13,500/2"	No
Farmington							
Bivin & Smoot Drlg Co	3	Frnks Rocket	Truck	2	10,000	10,000/2" 10,000/2½" 7,500/3"	Yes
	5	Frnks Rocket	Truck	2	10,000	10,000/2" 10,000/2½" 7,500/3"	Yes
Calif Prod Serv Inc	H-9-M	—	—	—	—	—	—
	H-4-M	—	—	—	—	—	—
Lohmann Oil Well Serv Inc	11	Intl 192	Truck	2	10,500	10,500	No
	12	White 1283	Truck	2	10,500	10,500	No
	16	Intl L 190	Truck	2	10,500	10,500	No
	18	Frnks Sr	Self-prop	—	12,000	12,000	Yes
Hobbs							
Albright Well Serv Co	12	Frnks 658	Truck	2	13,000	10,000	No
	23	Frnks 658	Truck	2	13,000	10,000	No
	27	Frnks 658	Truck	2	13,000	10,000	No
	34	Frnks 658	Truck	2	13,000	10,000	No
	44	Frnks Rocket	Truck	2	13,000	15,000	No
	49	Frnks Rocket	Truck	2	13,000	15,000	No

NOW–ANOTHER DRILLING AID FROM MILWHITE

CHEK-LOSS

The Loss Circulation Product Whose Elasticity Gives You a Better Seal Under Pressure

. . . when compressed, conforms to the shape of the containing body and effects a more permanent, effective seal.

BEFORE PRESSURE

Photomicrograph of Chek-Loss under atmospheric conditions (note voids between particles).

UNDER PRESSURE

Photomicrograph of Chek-Loss when compressed (note the voids between particles have been decreased due to its elasticity).

CHEK-LOSS

- Is Chemically Inert in All Systems of Mud
- Is Unaffected by Oil
- Is Heat Stable
- Is Long Lasting
- Is Non-Abrasive

MILWHITE

MUD SALES COMPANY

HOUSTON, TEXAS

DIVISION OF MISSISSIPPI RIVER FUEL CORPORATION

Drilling Progress Through Mud Research Is Continuous at Milwhite.

Contractor's Name	Rig No.	Make & Model No. of Unit	How Unit is Trans-ported	No. of Drums	Estimated Capacity		Can Unit Also Drill?
					Swab-bing	Pulling	
Bateman & Whitsitt Inc	1	Hopper Hoist-mobile GXFA	Self-prop	2	15,000	15,000/2"	Yes
						13,000/2½"	
						10,000/3"	
	5	Hopper Hoist-GXFA	Self-prop	2	15,000	15,000/2"	No
						13,000/2½"	
						10,000/3"	
	10	Hopper GXFA	Self-prop	2	15,000	14,000/2"	No
						12,000/2½"	
						9,000/3"	
	15	Frnks 658	Self-prop	2	13,000	13,000/2"	No
	20	Frnks 658	Self-prop	2	23,000	13,000/2"	No
	25	Frnks	Self-prop	1	13,000	—	No
	30	Frnks 658	Self-prop	2	13,000	13,000/2"	No
	40	Frnks 658	Self-prop	2	13,000	13,000/2"	No
	45	Hopper GXFA	Truck	2	15,000	14,000/2"	No
						12,000/2½"	
						9,000/3"	
	50	Hooper GXFA	Truck	2	15,000	14,000/2"	No
						12,000/2½"	
						9,000/3"	
	55	Frnks 658	Truck	2	13,000	13,000/2"	No
	65	Frnks 658	Truck	2	13,000	13,000/2"	No
Clarke Oil Well Serv Co	3	Frnks 658	Truck	2	13,500	13,500/2"	No
	6	Frnks	Truck	—	15,000	15,000/2"	No
	8	Hopper	Truck	2	15,000	15,000/2"	No
	9	Frnks 658	Truck	2	13,500	13,500/2"	No
	10	Frnks 658	Truck	2	11,500	13,000/2"	No
Craig Well Serv	1	Wisn Mogul	Truck	2	13,000	13,000	Yes
	2	Cooper	Truck	2	13,000	13,000	Yes
J F McAdams	38	Frnks 658	Truck	2	12,500	12,500	No
	39	Frnks 658	Truck	2	12,500	12,500	No
	47	Hopper G-FA 145	Truck	2	12,500	12,500	No
	64	Frnks 658	Truck	2	12,500	12,500	No
	65	Frnks 658	Truck	2	12,500	12,500	No
	82	Frnks 658	Truck	2	12,500	12,500	No
	83	Frnks Expl 658	Truck	2	12,500	12,500	No
	85	Wisn Mogul	Truck	2	12,500	12,500	No
Jal							
Clarke Oil Well Serv Co	7	Frnks	Truck	2	13,500	13,500/2"	No
	2	Frnks 658	Truck	2	12,000	14,000/2"	No
Williamson Well Serv Inc	14	Frnks 658	Truck	2	13,500	13,500/2½"	No
OHIO							
Deerfield							
Glenn Gillespie & Sons	8	Cooper Skytop	Self-prop	1	—	10,000	Yes
Upper Sandusky							
Lininger Oil & Gas Co	2	N Baltimore	Truck	—	—	1,800/2"	No
OKLAHOMA							
Clarksville							
Chris Well Serv Co Ltd	16	Crdwll KM-250	Truck	2	15,000	19,000/2⅛"	Yes
Cushing							
Kemp Cable Tools	3	Wlkr-Nr C-33	Trailer	3	5,000	—	Yes
	4	Wlkr-Nr C-34	Trailer	3	7,000	—	Yes
Dewey							
Seifried Well Serv	1	Cooper 226	Truck	1	—	3,000	No
	2	Cooper 226	Truck	1	—	3,000	No
	3	Cooper 226	Truck	2	3,000	3,000	No
	4	Cooper 226	Truck	1	—	3,000	No
	5	Crdwll	Truck	1	—	3,500	No
	6	Cooper 226	Truck	2	3,000	3,000	No
	7	Cooper 226	Truck	1	3,000	3,000	No
Dillard							
Quad Drlg Co	1	Frnks Gnt Clpr	Self-prop	2	14,000	14,000	Yes
Edmond							
D & R Well Serv Inc	1	Frnks 658	Truck	2	—	—	Yes
	2	Frnks 658	Truck	2	—	—	Yes
	3	Frnks 658	Truck	2	—	—	Yes
	4	Frnks 658	Truck	2	—	—	Yes
Hennessey							
Chris Well Serv Co Ltd	4	Frnks 658	Truck	2	11,500	14,000/2⅛"	No
	11	Frnks 658	Truck	2	11,500	14,000/2⅛"	No
Laverne							
Pool Well Serv Co	11	Wisn Spr 38	Truck	2	12,000	10,000/2½"	No
	14	Wisn Spr 38	Truck	2	12,000	10,000/2½"	No
	15	Wisn Spr 38	Trailer	2	12,000	14,000/2½"	No
	19	Wisn Spr	Truck	1	10,000	—	—
	24	Wisn Spr	Truck	1	10,000	—	No
	32	Wisn	Self-prop	2	12,000	14,000/2½"	No
Lindsay							
Christian Sarratt & Wallace Ltd	80	Crdwll KM-250	Truck	2	15,000	19,000/2⅛"	Yes
	81	Frnks 658	Truck	2	11,500	15,000/2⅛"	Yes
	82	Frnks 658	Truck	2	11,500	15,000/2⅛"	Yes
	3	Frnks 658	Truck	2	11,500	14,000/2⅛"	No
Chris Well Serv Co Ltd	5	Frnks 658	Truck	2	11,500	14,000/2⅛"	No
	6	Frnks 658	Truck	2	11,500	14,000/2⅛"	No
	8	Frnks 658	Truck	2	11,500	14,000/2⅛"	No
	14	Frnks 658	Truck	2	11,500	14,000/2⅛"	Yes
	20	Crdwll KM-250	Truck	2	15,000	19,000/2⅛"	Yes
Oklahoma City							
Clark Well Serv Co	21	Frnks 658-DD	Truck	—	12,000	12,000/2"	No
	22	Frnks 44-SD	Truck	—	10,000	—	No
	20	Frnks 658-DD	Truck	—	12,000	12,000/2"	No
	18	Frnks 44-DD	Truck	—	9,000	9,000	No
	24	Frnks 658-DD	Truck	—	12,000	12,000/2"	No
	27	Frnks 658-DD Rocket	Truck	—	12,000	12,000/2"	Yes
	32	Frnks 658-DD Rocket	Truck	—	12,000	12,000/2"	Yes
	33	Frnks 658-DD	Frnks Expl	—	12,000	12,000/2"	No
	34	Crdwll KM-20	—	2	—	—	—
Okmulgee							
Smallwood Drlg Co	1	B Erie 36-L	Trailer	2	—	7,600	Yes
Perry							
Loyd Jones Well Serv Co	3	Frnks 65	Truck	1	—	12,000/2"	No
	4	Frnks 658	Truck	1	—	14,000/2"	No
	5	Frnks 65	Truck	2	10,080	12,000/2"	No
	6	Frnks 65	Truck	2	10,000	12,000/2"	No
O'Loughlin Well Serv Co	101	Frnks 5000	Truck	2	7,000	7,000	No
	102	Frnks 5000	Truck	2	7,000	7,000	No
	103	Frnks 5000	Truck	1	7,000	7,000	No
Sapulpa							
R L Carpenter	1	Cooper W	Truck	1	3,000	3,000/2"	No
						2,500/2½"	
						2,000/3"	
Seminole							
McDaniel Well Serv	1	Frnks 65-DTM	Truck	2	6,500	10,000/2"	No
						6,500/2½"	
	2	Frnks 65-DTM	Truck	2	6,500	10,000/2"	No
						6,500/2½"	
	3	Frnks 44-DTM	Truck	2	5,500	10,000/2"	No
						6,500/2½"	
Price-Caudle Well Serv Inc	1	Frnks 65	Truck	1	—	10,000/2"	No
						10,000/2½"	
						10,000/3"	
	3	Frnks 44	Truck	2	8,000	10,000/2"	Yes
						10,000/2½"	
						10,000/3"	
Velma							
Edwards Well Serv	1	Cooper TR Pole Unit	Truck	2	7,000	6,000	No
	3	Cooper TC	Self-prop	2	10,000	15,000/2"	Yes
Woodward							
Christian Inc	101	Frnks 658	Truck	2	11,500	12,500/2⅛"	No
	102	Frnks 658	Truck	2	11,500	12,500/2⅛"	No
	104	Frnks 658	Truck	2	11,500	12,500/2⅛"	Yes
	105	Crdwll KM-250	Truck	2	11,500	15,000/2⅛"	Yes
	106	Frnks 658	Truck	2	11,500	12,500/2⅛"	No
	107	Frnks 658	Truck	2	15,000	12,500/2⅛"	No
TEXAS							
Abilene							
Galloway Bros	4	Wich Engineer	Truck	—	—	—	No
McDonald Well Serv Co	1	Frnks 44-DTM	Truck	2	8,500	9,000/2"	Yes
						6,000/2½"	
	2	Frnks 44-DTM	Truck	2	8,500	10,000/2"	Yes
						7,000/2½"	
	3	Wisn Spr 38	Truck	2	8,500	10,000/2"	Yes
						7,000/2½"	
	4	Wichtex C-60	Truck	2	5,500	4,500/2"	No
						3,000/2½"	
	5	Frnks 44-DTM	Truck	2	8,500	10,000/2"	Yes
						7,000/2½"	
	6	Frnks 44-DTM	Truck	2	8,500	10,000/2"	Yes
						7,000/2½"	
Alice							
W M & W Well Serv Co	1	Wisn Spr	Truck	2	7,000	7,000/2"	Yes
						6,000/2½"	
						5,000/3"	
	3	Wisn Spr	Truck	2	6,500	6,000/2"	Yes
						5,000/2½"	
	5	Wisn Spr	Truck	2	7,500	6,500/2"	Yes
	7	Wisn 38	Truck	2	8,500	8,800/2"	Yes
						7,500/2½"	
	9	Wisn Mogul	Skid	2	8,500	12,500/2"	Yes
						9,000/2½"	
Alvin							
Sam E Wood	1	Ideco H-20	Truck	2	—	11,000/2"	Yes
						9,000/2½"	

Contractor's Name	Rig No.	Make & Model No. of Unit	How Unit is Transported	No. of Drums	Estimated Capacity		Can Unit Also Drill?
					Swabbing	Pulling	
Andrews							
Carl S Ham Inc	3	Crdwll K-200	Truck	2	13,500	13,500	Yes
	5	Crdwll K-200	Truck	2	13,500	13,500	Yes
	6	Crdwll K-200	Truck	2	13,500	13,500	Yes
	7	Crdwll K-200	Truck	2	13,500	13,500	Yes
	8	Crdwll K-200	Truck	2	13,500	13,500	Yes
Pool Well Serv Co	5	Wlsn Spr	Truck	2	10,000	8,000/2½"	No
	16	Wlsn Spr 38	Truck	2	12,000	10,000/2½"	No
	25	Wlsn Spr 38	Trailer	2	14,000	12,000/2½"	No
	30	Wlsn Spr 38	Truck	2	12,000	14,000/2½"	No
Williamson Well Serv Inc	22	Frnks 658	Truck	2	13,500	13,500/2½"	No
	26	Frnks 658	Truck	2	13,000	13,500/2½"	No
	33	Frnks 658	Truck	2	13,500	13,500/2½"	No
	35	Frnks 658	Truck	2	13,500	13,500/2½"	No
	37	Frnks 658	Truck	2	13,500	13,500/2½"	No
Bay City							
J P Graham	12	Wlsn Spr	Truck	—	9,000	—	No
	18	Wlsn Spr	Truck	—	10,000	—	No
	26	Wlsn Spr	Truck	—	9,000	—	No
	31	Wlsn Spr	Truck	—	9,000	—	No
Baytown							
Beall Well Serv Co	3	Crdwll KS	Truck	—	6,500	10,000/2"	Yes
Moore Petroleum Serv	8	Wlsn Mogul	Skid	1	5,000	5,000	Yes
Big Lake							
Arrow Well Serv	7	Wlsn Spr	Truck	2	9,500	9,500/2"	No
	8	Wlsn Spr	Truck	2	8,000	5,000/2½"	No
	9	Frnks 658	Self-prop	2	13,000	13,000/2½"	Yes
Pool Well Serv Co	20	Wlsn Spr	Truck	2	10,000	8,000/2½"	No
	23	Wlsn Spr	Truck	1	10,000	—	No
	31	Frnks	Truck	2	12,000	14,000/2½"	No
Big Spring							
Forsan Oil Well Serv	66	65-DD 69' Drk	Truck	2	11,000	10,000/2½"	Yes
	856	Wlsn Spr	Truck	2	11,000	10,000/2½"	Yes
Boling							
Producers Well Serv Inc	6	Cooper T-38	Truck	—	—	8,000	Yes
	7	Skytop	Self-prop	—	—	12,000	Yes
Borger							
Tex Well Serv Co	1	B Erie 36-L	Skid	3	4,000	4,000	Yes
	2	B Erie 36-L	Skid	3	4,000	4,000	Yes
	3	Wichtex	Truck	2	3,500	3,500	Yes
	4	Wlkr-Nr C-33-A	Truck	3	3,500	3,500	Yes
Bridgeport							
John Haseman Inc	2	Wlsn Spr	Truck	—	6,000	6,000	Yes
	4	Crdwll K-200	Truck	—	6,000	6,000	Yes
Bryson							
Eichler Well Serv	5	Wichtex C-65	Truck	2	6,000	6,000/2"	No
	6	Wichtex C-65	Truck	2	6,000	—	Yes
Cayuga							
Mobile Well Serv	1	Wlsn Spr	Truck	1	—	9,000	No
	2	Wlsn Spr	Truck	1	—	9,000	No
	*3	Wlsn Mogul	Skid	—	—	12,000	Yes
	5	Wlsn Spr	Truck	1	—	9,000	No
	6	Wlsn Spr	Truck	1	—	9,000	No
	8	Wlsn Spr	Truck	1	—	9,000	No
	9	Wlsn Spr	Truck	1	9,000	—	No
	*10	Frnks Rocket	Truck	2	—	12,000	Yes
Charlotte							
Dawson Well Serv	Circ 1	—	Trailer	—	—	—	—
	Circ 2	—	Trailer	—	—	—	—
	1	Wlsn Spr	Trailer	2	7,500	10,000/2" 6,000/2½" 4,000/3"	Yes
	2	Wlsn Sr	Truck	2	6,000	6,500/2" 4,500/2½" 3,500/3"	Yes
	3	Wlsn Spr	Trailer	2	9,500	10,000/2" 6,000/2½" 4,000/3"	Yes
Coahoma							
B & H Well Serv Inc	14	Wlsn Sr	Truck	2	—	6,000	No
	16	Wlkr-Nr C-32 Spddr	Truck	3	4,000	4,000	Yes
	12	Wlsn Spr	Truck	2	10,000	10,000	No
	10	Wlsn Sr	Truck	2	6,000	5,000	No
	3	Wlsn Sr	Truck	2	6,000	5,000	No
	7	Wlsn Spr 38	Truck	2	11,000	11,000	No
Corpus Christi							
Spartan Well Serv Inc	1	Crdwll KL	Truck	1	6,000	10,000/2" 8,000/2½" 6,500/3"	No
Crane							
Gene McCutchin	2	Wlsn	Truck	2	13,000	14,000	Yes
J R Todd Co Inc	4	Crdwll AL	Truck	2	9,000	8,000/2" 6,000/2½" 4,500/3"	No
	6	Crdwll K-200	Truck	2	13,000	13,000/2" 12,000/2½" 10,000/3"	Yes
	7	Crdwll K-200	Truck	2	13,000	13,000/2" 12,000/2½" 10,000/3"	Yes
	8	Crdwll K-200	Truck	2	13,000	13,000/2" 12,000/2½" 10,000/3"	Yes
	9	Crdwll K-200	Truck	2	13,000	13,000/2" 12,000/2½" 10,000/3"	Yes
Denver City							
Harrison Well Serv	1	Wlsn Mogul	Truck	2	12,000	12,000	No
	2	Wlsn "42"	Truck	2	12,000	12,000	No
	3	Wlsn Mogul 90' Derrick	Truck	2	12,000	12,000	No
Williamson Well Serv Inc	13	Frnks 658	Truck	2	13,500	13,500/2½"	No
	15	Frnks 658	Truck	2	13,500	13,500/2½"	No
	18	Frnks 658	Truck	2	13,500	13,500/2½"	No
	19	Frnks 658	Truck	2	13,500	13,500/2½"	No
	20	Frnks 658	Truck	2	13,500	13,500/2½"	No
	21	Frnks 658	Truck	2	13,500	13,500/2½"	No
	27	Frnks 658	Truck	2	13,500	13,500/2½"	No
Eldorado							
Arrow Well Serv	3	Wlsn Spr	Truck	2	9,500	9,500/2"	Yes
	4	Wlsn Spr	Truck	1	10,000	—	No
Electra							
Seale Well Serv	1	Wichtex TE-2	Truck	1	—	2,000	No
	2	Wlsn Sr	Truck	2	4,000	3,000	No
	3	Wichtex TE-2	Truck	2	3,000	3,000	No
	4	Wichtex TE-2	Truck	2	3,000	3,000	No
	5	Wichtex C-65	Truck	2	7,000	6,500	No
Forsan							
Forsan Oil Well Serv	11	Frnks 33	Truck	1	—	3,500/2½"	Yes
	33	Crdwll 856	Truck	1	—	3,500/2½"	Yes
	44	Frnks 44-TM	Truck	1	—	6,500/2½"	Yes
	188	Frnks 658-DTM	Truck	2	12,000	13,000/2½"	Yes
	658	Frnks 658	Trl-Trk	1	—	13,000/2½"	Yes
Freer							
Steitle Drlg Co	1	Wlsn Mogul 42	Trailer	2	13,500	15,000/2"	Yes
Grandfalls							
Nichols & Freeman	4	Wlsn	Truck	2	5,000	5,000	No
	6	Wlsn	Truck	2	5,000	5,000	No
	14	Wlsn	Truck	2	4,000	4,000	No
	15	Wlsn	Truck	1	—	4,500	No
	22	Wlsn Sr	Truck	dbl	10,000	10,000	Yes
Hardin							
Beall Well Serv Co	2	Natl T-8	Truck	1	—	10,000	No
Holliday							
Baggett Drlg Co	1	Wlkr-Nr 37	Trailer	3	—	8,000	Yes
	2	Wlkr-Nr 27	Truck	2	—	7,000	Yes
	3	Wlkr-Nr 34	Trailer	3	—	8,000	Yes
	4	Wlkr-Nr 27	Truck	2	—	7,000	Yes
Houston							
Moore Petroleum Serv	1	Crdwll K	Truck	1	8,000	—	Yes
	2	Crdwll K	Truck	2	10,000	8,600	Yes
	3	Crdwll K	Truck	1	8,000	8,000	Yes
	4	Crdwll M-200	Self-prop	2	10,500	12,000	Yes
	5	Crdwll L	Trailer	2	10,500	12,000	Yes
	6	Crdwll K-202	Truck	2	10,000	10,000	Yes
	7	Crdwll M-200	Self-prop	2	10,500	12,000	Yes
Stewart's Casing Crew	1	Cooper E	Truck	1	—	8,000/2" 6,500/2½"	Yes
	3	Cooper 420	Truck	1	—	11,000/2" 9,000/2½"	Yes
	5	Cooper 420	Truck	1	—	11,000/2" 9,000/2½"	Yes
	6	Cooper 420	Truck	1	—	11,000/2" 9,000/2½"	Yes
	7	Cooper TR-42	Truck	1	—	10,000/2" 8,000/2½"	No
	8	Cooper AP-138	Truck	1	—	10,000/2" 8,000/2½"	No
	9	Frnks	Skid Mtd	1	—	10,000/2" 8,000/2½"	Yes
Iraan							
Iraan Well Serv Inc	1	Wlsn Sr	Truck	1	2,100	3,000/2" 2,800/2½" 2,000/3"	No

Contractor's Name	Rig No.	Make & Model No. of Unit	How Unit is Transported	No. of Drums	Estimated Capacity		Can Unit Also Drill?
					Swabbing	Pulling	
	2	Wichtex C-60	Truck	2	3,500	3,500/2" 3,000/2½" 2,000/3"	No
	3	Wichtex C-60	Truck	2	6,000	6,000/2" 5,600/2½" 4,000/3"	No
Kamay							
J W (Johnny) Birdwell Well Serv	3	Wichtex C-65	Truck	2	6,500	6,500/2"	No
	4	Wlkr-Nr	Truck	1	—	6,500/2"	No
	5	Wichtex C-65	Truck	—	6,500	6,500/2"	No
	6	Wichtex C-65	Truck	—	6,500	6,500/2"	No
W R Potter Well Serv	1	Wlsn Spr	Truck	1	—	6,000	No
	3	Wlsn Mas	Truck	2	5,400	6,700	No
Kenedy							
Copeland & Fuller Well Serv	1	Wlsn Spr 38	Truck	2	8,000	8,500/2" 7,500/2½"	Yes
	2	Cooper A-38	Truck	2	8,000	10,000/2" 8,500/2½"	Yes
Kermit							
Camden Drlg Co	1	Natl T-20	Skid	—	—	—	Yes
Oilwell Serv & Engnr Inc	1	Frnks 658-DTM	Truck	2	13,000	12,500/2½"	No
	2	Wichtex C-60	Truck	2	6,000	6,000/2½"	No
	3	Frnks 658-DTM	Truck	2	13,000	12,500/2½"	No
Kilgore							
Bivin & Smoot Drlg Co	2	Wlsn Mogul	—	2	11,500	10,000/2" 10,000/2½" 7,500/3"	Yes
Carter-Jones Drlg Co Inc	1	Wlsn Spr	Truck	1	10,000	7,500	No
	2	Wlsn Spr	Truck	1	10,000	7,500	No
Longlake							
Mobile Well Serv	4	Wlsn Spr	Truck	1	—	9,000	No
Luling							
Cleveland Well Serv	1	Frnks 33-TM	Truck	1	No	4,500/2"	No
	2	Crdwll AH	Truck	2	5,000	6,000/2"	Yes
Midland							
Basin Well Serv Inc	32	Hopper G	Truck	—	10,000	8,000/2"	No
	37	Hopper G	Trailer	—	15,000	12,000/2"	Yes
	38	Hopper G	Trailer	—	15,000	12,000/2"	Yes
	44	Hopper G	Truck	—	12,000	10,000/2"	No
	46	Hopper G	Truck	—	12,000	10,000/2"	No
C H Brockett Inc	1	Crdwll K	Truck	—	—	7,500/2"	No
	2	Crdwll KS	Truck	1	—	10,000/2"	No
	3	Wlsn Gnt	Truck	1	—	16,000/2"	No
Kinsey & Ham Inc	1	Crdwll L	Trailer	2	13,500	13,500/2"	Yes
Iraan Well Serv Inc	4	Wlsn Mogul	Truck	2	10,000	14,000/2" 10,000/2½" 8,000/3"	No
	5	Ideco	Truck	2	10,000	12,000/2" 9,000/2½" 8,000/3"	No
Kinsey & Ham Inc	2	Crdwll	Trailer	2	15,000	15,000/2"	Yes
Dean Penick Casing Pulling	1	Wlsn Spr	Truck	1	—	9,000/5½"	No
Pool Well Serv Co	12	Wlsn Spr 38	Truck	2	12,000	10,000/2½"	No
	17	Wlsn Mogul 42	Trailer	2	14,000	14,000/2½"	No
	18	Wlsn Mogul 42	Trailer	2	14,000	14,000/2½"	Yes
	22	Wlsn Mogul 42	Trailer	2	14,000	14,000/2½"	No
	27	Wlsn Mogul 42	Trailer	2	14,000	14,000/2½"	Yes
Williamson Well Serv Inc	28	Frnks 658	Truck	2	13,500	13,500/2½"	No
	30	Frnks 658	Truck	2	13,500	13,500/2½"	No
	31	Frnks 658	Truck	2	13,500	13,500/2½"	No
Mission							
J & M Well Serv	10	Cooper Skytop	Self-prop	2	8,500	10,000/2½"	Yes
	11	Wlsn Wnchmobl	Self-prop	2	10,000	16,000/2½"	Yes
	12	Wlsn Wnchmobl	Self-prop	2	10,000	16,000/2½"	Yes
Monahans							
Brad-Tex Drlg Co Inc	1	Wlsn Spr	Trailer	1	—	—	Yes
	2	Ideco H-30	Skid	1	—	—	Yes
	3	Natl 50	Skid	1	—	—	Yes
	4	Natl 50	—	1	—	—	Yes
	5	Crdwll O	Skid	1	—	—	—
White Well Serv	—	Wlkr-Nr	Truck	2	5,000	5,000	No
	—	Wlkr-Nr	Trk Mtd	2	5,000	5,000	No
	—	Frnks 44	Trk Mtd	2	9,000	9,000	No
	—	Crdwll K-200	Trk Mtd	2	13,000	13,000	No
	—	Crdwll AH	Trk Mtd	2	9,000	9,000	No
	—	Crdwll AH	Trk Mtd	2	9,000	9,000	No
	—	Crdwll AH	Trk Mtd	2	9,000	9,000	No
	—	Crdwll K-200	Truck	2	13,000	13,000	No
	—	Frnks 5000	Truck	1	10,000	10,000	No
	—	Crdwll AH	Trk Mtd	2	9,000	9,000	No

Contractor's Name	Rig No.	Make & Model No. of Unit	How Unit is Transported	No. of Drums	Estimated Capacity		Can Unit Also Drill?
					Swabbing	Pulling	
Naches							
Mobile Well Serv	11	Wlsn Spr	Truck	1	9,000	—	No
New London							
Maxwell Well Serv Co	1	Wlsn Spr	Trailer	1	9,500	6,500/3"	—
	2	Wlsn Spr	Trailer	1	9,500	6,500/3"	—
	3	Wlsn Spr	Trailer	1	9,500	6,500/3"	—
	4	Wlsn Spr	Trailer	1	9,500	6,500/3"	—
	5	Wlsn Spr	Trailer	1	9,500	6,500/3"	—
Nocona							
Jack Mercer Well Serv	2	Wlsn Sr	Truck	1	No	3,000/2"	No
	7	Wichtex C-65	Truck	2	8,000	8,000/2"	Yes
	8	Wichtex E-75	Truck	2	10,000	10,000/2"	Yes
	15	Wichtex E-75	Truck	2	10,000	10,000/2"	Yes
	18	Wichtex E-75	—	2	10,000	10,000/2"	Yes
	20	Wichtex E-75	Truck	2	10,000	10,000/2"	Yes
	33	Wichtex E-75	Truck	2	10,000	10,000/2"	Yes
Novice							
Pool Well Serv Co	9	Wlsn Sr	Truck	2	6,500	5,000/2½"	No
Odessa							
Chas J George Inc	10	Frnks 658	Truck	2	13,500	13,000	No
	12	Frnks 658	Truck	2	13,500	13,000	No
	14	Frnks 658	Truck	2	13,500	13,000	No
	16	Frnks 658	Truck	2	13,500	13,000	No
	17	Frnks 658	Truck	2	13,500	13,000	No
	18	Frnks 658	Truck	2	13,500	13,000	No
	19	Wlsn Mogul	Self-prop	2	14,000	—	Yes
	20	Wlsn Mogul	Self-prop	2	14,000	—	Yes
J E Perkins Inc	3	Wlsn Gnt	Skid	1	—	10,000/2½" 8,500/2¼"	Yes
	4	U-15	Skid	1	—	14,000/2½" 12,000/2¼"	Yes
	5	Wlsn Gnt	Skid	1	—	13,000/2½" 12,000/2¼"	Yes
	6	Wlsn Gnt	Skid	1	—	15,000/2½" 13,500/2¼"	Yes
J R Todd Co Inc	1	Frnks 658-DTM	Truck	2	13,000	13,000/2" 12,000/2½" 10,000/3"	No
	2	Frnks 658-DTM	Truck	2	13,000	13,000/2" 12,000/2½" 10,000/3"	No
	3	Frnks 658-DTM	Truck	2	13,000	13,000/2" 12,000/2½" 10,000/3"	No
Williamson Well Serv Inc	3	Frnks 658	Truck	2	13,500	13,500/2½"	No
	7	Frnks 658	Truck	2	13,500	13,500/2½"	No
	9	Frnks 658	Truck	2	13,500	13,500/2½"	No
	10	Frnks 658	Truck	2	13,500	13,500/2½"	No
	11	Frnks 658	Truck	2	13,500	13,500/2½"	No
	17	Frnks 658	Truck	2	13,500	13,500/2½"	No
	23	Frnks 658	Truck	2	13,500	13,500/2½"	No
	24	Frnks 658	Truck	2	13,500	13,500/2½"	No
	32	Frnks 658	Truck	2	13,500	13,500/2½"	No
	34	Frnks 658	Truck	2	13,500	13,500/2½"	No
	36	Frnks 658	Truck	2	13,500	13,500/2½"	No
Olney							
F M Johnson Well Serv	1	Johnson 30	Truck	3	2,500	2,500	Yes
	2	Clark 30	Trailer	3	3,600	3,600	Yes
	3	Clark 30	Trailer	3	3,600	3,600	Yes
	4	Clark 30 Spr	Trailer	3	5,000	5,000	Yes
	5	Clark 30 Spr	Trailer	3	5,000	5,000	Yes
Perryton							
Loyd Jones Well Serv Co	1	Frnks 65	Truck	2	12,500	12,000/2"	No
	11	Frnks 658	Truck	2	13,500	14,000/2"	No
	7	Frnks 658	Truck	2	13,500	14,000/2"	No
Pettus							
Carter Well Serv	1	Wlsn Spr	Truck	2	10,000	9,500/2"	No
	2	Wlsn Spr	Truck	2	10,000	9,500/2"	No
	3	Wlsn Spr	Truck	2	10,000	9,500/2"	No
	4	Wlsn Skytop	Truck	2	10,000	9,500/2"	No
Pleasanton							
J E Hillier	3	Crdwll 250-KM	Self-prop	2	15,000	15,000/2½"	Yes
Rio Grande City							
J & M Well Serv	2	Cooper E-563	Truck	2	6,000	5,000/2½"	Yes
	3	Cooper E-563	Truck	2	6,000	5,000/2½"	Yes
	4	Wlsn Spr	Truck	2	6,000	7,000/2½"	Yes
	5	Wlsn Spr	Truck	2	6,000	7,000/2½"	Yes
	7	Wlsn Spr	Truck	2	6,000	7,000/2½"	Yes
	8	Wlsn Sr	Truck	2	6,000	4,000/2½"	Yes
	9	Cooper T-36	Truck	1	10,000	—	No

Contractor's Name	Rig No.	Make & Model No. of Unit	How Unit is Transported	No. of Drums	Estimated Capacity Swabbing	Estimated Capacity Pulling	Can Unit Also Drill?
Rockport							
Camden Drlg Co	2	Natl T-32	Barge	—	—	—	Yes
Royalty							
Locke Well Serv	1	Wlsn Spr	Truck	2	12,000	12,000	Yes
	2	Hopper	Truck	2	12,000	12,000	Yes
	3	Wlsn Spr	Truck	2	8,000	8,000	Yes
Rosenberg							
Savely Workover & Drlg Inc	4	Frnks Sr Clpr	Self-prop	1	—	1,200/2½"	Yes
	5	Frnks Sr Clpr	Self-prop	1	—	1,200/2½"	Yes
San Angelo							
Arrow Well Serv	2	Wlsn Spr	Truck	2	9,500	9,500/2"	No
Pool Well Serv Co	1	Wlsn Spr	Truck	2	10,000	8,000/2½"	No
	2	Wlsn Spr 38	Self-prop	2	10,000	10,000/2½"	No
	4	Wlsn Spr	Truck	1	10,000	—	No
	6	Wlsn Spr	Truck	2	10,000	10,000/2½"	No
	26	Wlsn Spr	Truck	2	6,500	5,000/2½"	No
Saratoga							
Beall Well Serv Co	4	Natl T-8-S	Truck	2	8,000	10,000	No
Snyder							
B & H Well Serv	5	Wlsn Spr 38	Truck	2	11,000	11,000	No
	6	Wlsn Spr 38	Truck	2	11,000	11,000	No
	9	Super 38	Truck	2	11,000	11,000	No
	2	Wlsn Spr	Truck	2	10,000	10,000	No
Leon Goswick & Co	7	Wlsn Spr	Truck	2	9,000	9,500/2" 8,000/2½"	No
	8	Wlsn Spr 38	Guyless	—	—	10,000/2½"	No
Universal Oilwell Serv Inc	136	Frnks 65/65	Truck	2	11,000	10,000/2" 9,000/2½" 8,000/3"	Yes
	182	Frnks 658/65	Truck	2	11,000	15,000/2" 12,000/2½" 10,000/3"	Yes
	237	Frnks Expl	Self-prop 90' Derrick	2	12,000	12,000/2½"	Yes
	245	Frnks 658 Expl	Self-prop 90' Derrick	2	10,000	10,000/3"	Yes
	246	Frnks 658 Expl	Self-prop 69' Derrick	2	10,000	10,000/3"	Yes
Sour Lake							
Ansco Swabbing Serv	1	Wlsn Mogul	Truck	1	10,000	—	No
	2	Ideco	Truck	1	10,000	—	No
	3	Crdwll HS	Truck	1	9,000	—	No
	4	Wlsn Mogul	Truck	1	10,000	—	No
South Houston							
Carlton Well Serv	1	Frnks Hyd	Truck	1	—	—	No
	2	Frnks Hyd	Truck	1	—	—	No
	3	Frnks Hyd	Truck	1	—	—	No
Sweetwater							
Leon Goswick & Co	5	Wlsn Spr	Truck	2	9,000	9,500/2" 8,000/2½"	No
	6	Wlsn Spr	Truck	2	9,000	9,500/2" 8,000/2½"	No
	9	Wlsn Spr	Truck	2	9,000	— 6,500/2½"	No
Pool Well Serv Co	7	Wlsn Spr	Truck	2	10,000	8,000/2½"	No
	21	Wlsn Spr	Truck	2	10,000	8,000/2½"	No
White Well Serv	—	Hopper	Trk Mtd	2	13,000	13,000	No
	—	Frnks 5000	Trk Mtd	1	10,000	10,000	No
	—	Frnks 44	Trk Mtd	2	9,000	9,000	No
Victoria							
Spears Well Serv Inc	1	Wlsn Spr	Truck	2	8,000	8,500/2" 6,500/2½"	Yes
	2	Wlsn Spr	Truck	2	8,000	8,500/2" 6,500/2½"	Yes
	3	Wlsn Spr	Truck	2	8,000	8,500/2" 6,500/2½"	Yes
	4	Wlsn Spr	Truck	1	8,000	—	—
	5	Skytop Wltrwt	Truck	2	8,000	11,000/2" 8,000/2½"	Yes
	6	Skytop Wltrwt	Truck	2	8,000	11,000/2" 8,000/2½"	Yes
Waskom							
Crusader Drlg & Serv Inc	8	Wlsn Spr	Truck	1	—	8,500/2½"	Yes
Whitesboro							
Jack Mercer Well Serv	6	Wichtex E-74	Truck	2	10,000	10,000/2"	Yes
Wichita Falls							
McAlister Well Serv	10	Wlsn Spr	Truck	2	7,500	7,500/2" 6,500/2½"	No
	20	C-25	Truck	2	7,500	7,500/2" 6,500/2½"	Yes
	42	Wichtex	Truck	2	5,000	5,000/2" 3,600/2½"	No
	45	Wichtex	Truck	1	—	5,000/2" 3,600/2½"	No
Ramay Well Serv	1	Wichtex E-75 Dble Drum	Truck	2	8,500	8,000	Yes
	3	Wichtex C-60 Dble Drum	Truck	2	6,000	4,500	Yes
	2	Wichtex E-75 Dlbe Drum	Truck	2	8,500	8,000	Yes
Wink							
Ideal Casing Co	3	Jack Knife	Skid	1	—	11,000	Yes
Longhorn Service & Drlg Co	1	Frnks 658	Truck	2	12,500	11,000/2" 9,000/2½" 7,500/3"	No
	3	Frnks 658	Truck	2	12,500	11,000/2" 9,000/2½" 7,500/3"	No
	5	Frnks 66	Truck	2	12,500	10,000/2" 8,000/2½" 6,000/3"	No
	6	Hopper 96	Truck	2	15,000	—	No
Permian Well Serv Inc	1	Crdwll	Skid	2	12,000	12,000/2"	Yes
	2	Wlsn Spr	Truck	2	12,000	11,000/2"	No
	3	Wlsn Spr	Truck	2	10,000	9,000/2"	No
	5	Crdwll	Truck	1	—	5,000/2"	No
	6	Wlsn Spr	Truck	2	10,000	9,000/2"	No
	7	Wilson	Truck	2	—	10,000/2"	No
Winnsboro							
Winnsboro Well Serv Co	F-1	Frnks Rocket	Truck	2	6,500	8,500/2" 7,200/2½"	Yes
	F-2	Frnks Rocket	Truck	2	6,500	8,500/2" 7,200/2½"	Yes
	F-5	Frnks Spr	Truck	1	—	8,500/2" 7,200/2½"	Yes
	F-6	Frnks 44	Truck	1	—	6,000/2" 5,000/2½"	Yes
	W-4	Wlsn Spr	Truck	1	8,500	—	—
Winters							
Arrow Well Serv	1	Wichtex C-65	Truck	2	8,000	7,000/2"	No
	6	Wlsn Spr	Truck	2	9,500	9,500/2"	No
Pool Well Serv Co	3	Wlsn Spr	Truck	2	10,000	8,000/2½"	No
	8	Wlsn Spr	Truck	2	6,500	5,000/2½"	No
	28	Wlsn Spr 38	Truck	2	12,000	10,000/2½"	No
	29	Wlsn Spr	Truck	2	10,000	8,000/2½"	No
Young							
Gene McCutchin	1	Wilson	Truck	2	10,000	10,000	Yes
UTAH							
Vernal							
Calif Prod Serv Inc	M-3	Hopper G	Trailer	2	10,000	10,000	Yes
WYOMING							
Casper							
Galloway Bros	2	Okla Mach & Supply	Truck	1	—	—	No
Capshaw Well Serv Co	1	Crdwll	Truck	2	10,000	10,000/2½"	No
	2	Wlsn	Self-prop	2	10,000	10,000/2½"	No
Cody							
D & S Well Serv	1	Wlsn Spr 38	Truck	2	10,500	12,500	Yes
	2	Wlsn Spr 38	Self-prop	2	12,500	15,000	Yes
	3	Wlsn Spr	Truck	2	8,500	8,000	Yes
Edgerton							
Van Norman Oil-Well Serv	1	Hopper 56	Truck	2	8,000	8,000	Yes
	2	Crdwll	Truck	1	4,000	4,000	No
	3	Crdwll	Truck	1	4,000	4,000	No
	4	Wlsn Spdr Mogul	Trailer	3	8,000	4,000	Yes
	8	Hopper	Truck	2	8,000	8,000	Yes
Gillette							
Stafford Well Serv	61	Frnks 658-44	Truck	2	13,000	13,000	—
Lynch							
Stafford Well Serv	5	Frnks 65-44	Truck	2	8,000	8,000	Yes
	10	Frnks 65-44	Truck	2	8,000	8,000	Yes
	44	Frnks 658	Truck	2	13,000	13,000	Yes
	73	Frnks 658-44	Truck	2	13,000	13,000	Yes
Powell							
Dicks Well Serv Co	7	Frnks & Cooper	Truck	2	10,000	10,000	No
Riverton							
Stafford Well Serv	14	Frnks 65-44	Truck	2	8,000	8,000	Yes
Roset							
M E Billings Well Serv Inc	1	Frnks DD Rokt	Truck	—	10,000	13,000/2"	Yes
Weston							
Prairie Drlg Co Inc	1	Crdwll RS	Skid	—	—	—	Yes

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Flint Rig Co Ltd 5th Fl Natural Gas Bldg Calgary Alberta Canada
Gamache Well Serv Ltd 12 - 11244 116th St
Edmonton Alberta Canada
General Well Servs Ltd 10955 - 66th Ave
Edmonton Alberta Canada
Light Well Serv Co Ltd 3631 16th St SE Calgary Alberta Canada
Mac Lean Well Serv Ltd Drayton Valley Alberta Canada
Prairie Well Serv Co Ltd Box 4177 Edmonton Alberta Canada
Raines Well Serv Ltd 11166 - 73rd Ave Edmonton Alberta Canada
Redwell Serv Co Ltd 6530 - 100th St Edmonton Alberta Canada
Souris Serv Co Ltd Box 1138 Estevan Saskatchewan Canada
Tulco Well Services Ltd 8039 102nd St Edmonton Alberta Canada
Widney Oil & Drlg Co Ltd 6328 - 104th St
Edmonton Alberta Canada

Canadian Contract Well Servicing or Pulling Units

Contractor's Name	Rig No.	Make & Model No. of Unit	How Unit is Transported	No. of Drums	Estimated Capacity Swabbing	Estimated Capacity Pulling	Can Unit Also Drill?
ALBERTA							
Blackfalds							
Redwell Serv Co Ltd	7	Frnks Rokt 44	Truck	2	9,000	9,500/2" 7,000/2½"	Yes
Breton							
Redwell Serv Co Ltd	1	Crdwll H	Truck	1	9,000	7,000/2" 5,000/2½"	No
Calgary							
Light Well Serv	101	Ideco M-25	Truck	2	10,000	8,000	Yes
	102	Failing 1500	Truck	2	6,000	2,000	Yes
	115	Frnks Rocket	Truck	2	8,000	7,000	Yes
	120	Ideco M-25	Truck	2	10,000	8,000	Yes
Widney Oil & Drlg Co Ltd	12	Ideco H-35	Self-prop	2	15,000	18,000/2" 15,000/2½"	Yes
Camrose							
Gamache Well Serv Ltd	2	Frnks Rocket	Truck	2	5,000	4,500/2"	Yes
Cynthia							
Redwell Serv Co Ltd	12	Frnks Rocket	Truck	2	7,000	9,000/2" 7,000/2½"	Yes
Drayton Valley							
Beta Well Serv Ltd	8	Crdwll K-201	Truck	2	—	10,000/2" 8,500/2½"	Yes
Mac Lean Well Serv Ltd	1	Crdwll AH	Truck	2	6,500	6,000/2"	Yes
	2	Crdwll AH	Truck	2	6,500	6,000/2"	Yes
	3	Cooper Skytop	Truck	2	10,000	10,000/2"	Yes
	4	Cooper Skytop	Truck	2	10,000	10,000/2"	Yes
Redwell Serv Co Ltd	5	Crdwll AL	Truck	2	9,000	7,000/2" 5,000/2½"	Yes
	11	Frnks Rocket 44	Truck	2	9,000	9,500/2" 7,000/2½"	Yes
	14	Crdwll AL	Truck	2	9,000	7,000/2" 5,000/2½"	Yes
Widney Oil & Drlg Co Ltd	1	Ideco H-20	Truck	2	9,000	10,000/2" 9,000/2½"	Yes
	6	Wlsn Spr	Truck	2	9,000	8,000/2" 6,500/2½"	Yes
	9	Wlsn Spr	Truck	2	9,000	8,000/2" 6,500/2½"	Yes
	10	Frnks Rocket 44	Truck	2	9,000	8,000/2" 6,500/2½"	Yes
Chupp Well Serv Ltd	3	Wichtex C-60	Truck	1	5,000	5,000/2"	No
	4	Wichtex C-65	Truck	—	7,500	7,000/2"	No
	5	Ideco M-25-D	Truck	2	10,000	10,000/2"	Yes
Edmonton							
General Well Serv Ltd	1	Hydraulic Csg Pulling	Trailer	1	—	—	No
Prairie Well Serv Co Ltd	1	Crdwll H	Truck	1	6,000	6,000/2" 5,000/2½"	No
	2	Crdwll H	Truck	1	6,000	6,000/2" 5,000/2½"	No
	5	Crdwll KL	Skid Mtd	2	15,000	12,000/2" 10,000/2½"	Yes
	6	Crdwll RL	Skid Mtd	2	14,000	14,000/2" 12,000/2½"	Yes
	9	Frnks	Truck	2	14,000	14,000/2" 12,000/2½"	Yes
Raines Well Serv Ltd	2	Cooper TD	Self-prop	2	10,000	10,000	No
Tulco Well Serv Ltd	1	Wlsn Spr	Trailer	2	8,000	7,000/2½"	No
	2	Cooper Skytop T-420	Truck	2	8,000	15,000/2½"	Yes
Leduc							
Gamache Well Serv Ltd	3	Frnks Rocket	Truck	2	6,500	8,000/2"	Yes
Lodgepole							
Redwell Serv Co Ltd	10	Frnks Rocket 44	Truck	2	9,000	9,500/2" 7,000/2½"	Yes
Olds							
Redwell Serv Co Ltd	3	Crdwll H	Truck	2	9,000	7,000/2" 5,000/2½"	Yes
Red Deer							
Chupp Well Serv Ltd	2	Crdwll RL-709	Trailer	2		10,000	—
	3	Wichtex C-60	Truck	1	5,000	5,000/2"	No
	4	Wichtex C-65	Truck	2	7,500	7,000/2"	No
	5	Ideco M-25-D	Truck	2	10,000	10,000/2"	Yes
Redwell Serv Co Ltd	15	Crdwll K-201	Truck	2	9,000	10,000/2" 7,500/2½"	Yes
Redwater							
Beta Well Serv Ltd	2	Crdwll H	Truck	1	—	5,000/2" 4,000/2½"	Yes
	3	Crdwll Mobilhst	Truck	2	—	5,000/2" 4,000/2½"	Yes
	6	Crdwll AH	Truck	2	—	6,000/2" 5,000/2½"	Yes
Stettler							
Prairie Well Serv Co Ltd	3	Crdwll	Self-prop	2	6,500	6,500/2" 5,500/2½"	Yes
	4	Ideco 50-60	Truck	2	7,000	7,000/2" 6,000/2½"	Yes
Redwell Serv Co Ltd	2	Crdwll H	Truck	1	9,000	7,000/2" 5,000/2½"	No
	6	Crdwll AL	Truck	2	9,000	7,000/2" 5,000/2½"	Yes
Sundre							
Redwell Serv Co Ltd	9	Frnks Clpr 65	Truck	2	9,000	13,000/2" 10,000/2½"	Yes
Swan Hills							
Prairie Well Serv Co Ltd	10	Cooper	Self-prop	2	9,000	10,000/2" 9,000/2½"	Yes
Wetaskiwin							
Redwell Serv Co Ltd	13	Crdwll AL	Truck	2	9,000	7,000/2" 5,000/2½"	Yes
Whitecourt							
Redwell Serv Co Ltd	8	Frnks Clpr 65	Truck	2	9,000	13,000/2" 10,000/2½"	Yes
MANITOBA							
Virden							
Flint Rig Co Ltd	55	Wlsn	Truck	2	8,000	—	Yes
	280	Crdwll HS	Truck	1	3,600	—	No
	293	Cooper	Truck	1	3,600	—	No
	307	Frnks 44-DTM	Truck	2	6,000	—	Yes
SASKATCHEWAN							
Estevan							
Flint Rig Co Ltd	55	Wlsn	Truck	2	8,000	12,000	Yes
	320	Frnks 44-DTM	Truck	2	6,000	—	Yes
	353	Cooper	Truck	2	8,000	—	Yes
Souris Serv Co Ltd	4	Mayhew 2000	Truck	2	5,000	5,000	Yes Slim hole
Oxbow							
Souris Serv Co Ltd	1	Crdwll AL 50' Mast	Truck	2	5,000	5,000/2½"	Yes
	2	Frnks Rokt 33-DTD 50' Mast	Truck	2	5,000	5,000/2½"	Yes
	5	Mayhew 2000	Truck	2	5,000	5,000	Yes Slim hole
Widney Oil & Drlg Co Ltd	7	Cooper W-226	Truck	2	5,000	3,000/2½"	No
	8	Wlsn Spr	Truck	2	9,000	8,000/2" 6,500/2½"	Yes
	11	Frnks Rokt 44	Truck	2	9,000	8,000/2" 6,500/2½"	Yes
	14	Frnks Rokt 44	Truck	2	9,000	8,000/2" 6,500/2½"	Yes
Swift Current							
Flint Rig Co Ltd	290	Crdwll AH	Truck	2	6,000	—	Yes
	317	Frnks 44-DTM	Truck	2	6,000	—	Yes
Weyburn							
Souris Serv Co Ltd	3	Crdwll AL 50' Mast	Truck	2	5,000	5,000/2½"	Yes

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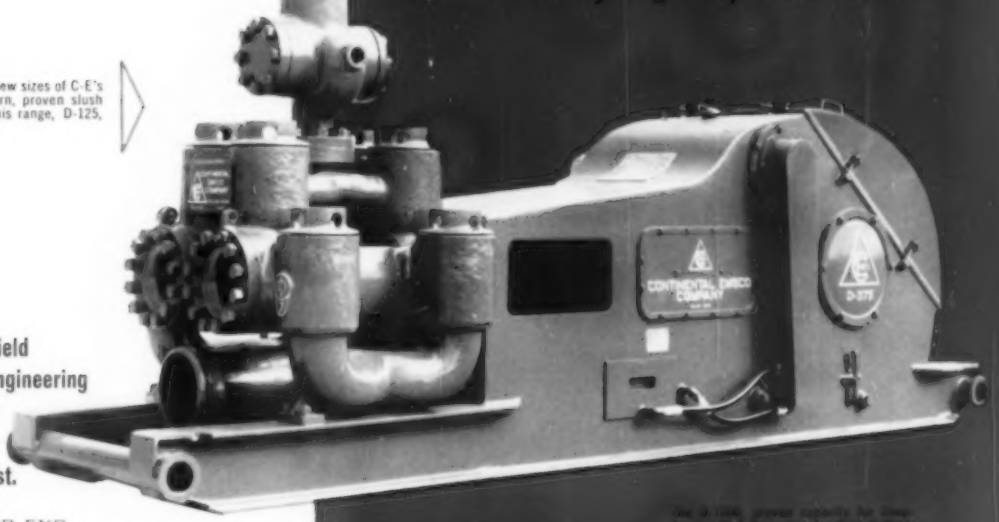

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D-375—Maximum Input . . 375 hp @ 70 rpm
D-225—Maximum Input . . 225 hp @ 70 rpm
D-125—Maximum Input . . 125 hp @ 85 rpm

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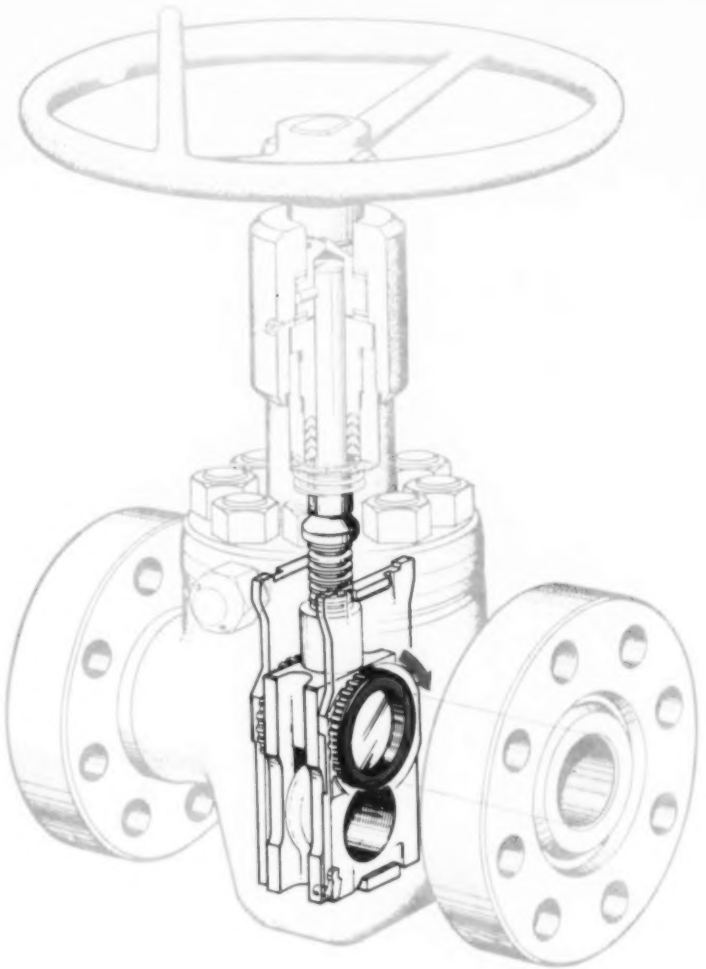
OPEN-CLOSE-OPEN-CLOSE-OPEN-CLOSE-OPEN-CLOSE-



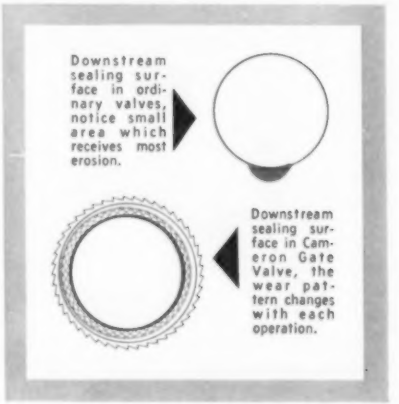
VALVE COST CLUE

The maze of costs connected with the average valve for API service requires more than a clue for a clear understanding, but here is one salient fact applicable to all.

Any API valve serves only one purpose — to open and close the line. The actual cost of the valve is the cost per operating cycle during its useable life multiplied by the number of times it is operated. For a true picture, the average operating cycle cost must include purchase price, all maintenance and repair.

The Cameron Type "F" Gate Valve offers the most operating cycles for the least money — the reason is its exclusive rotating-seat principle, the biggest advancement in API valve design today. With each operation sealing surfaces are changed and wear is spread over the entire contact area. Valve life is extended tremendously.

If you plan, recommend or purchase valve installations for API service you'll want more than a clue to costs — call the nearest Cameron Representative, he can


Downstream sealing surface in ordinary valves, notice small area which receives most erosion.
Downstream sealing surface in Cameron Gate Valve, the wear pattern changes with each operation.

give you complete details on Cameron Type "F" Gate Valves and their "lowest cost operation."

Cameron

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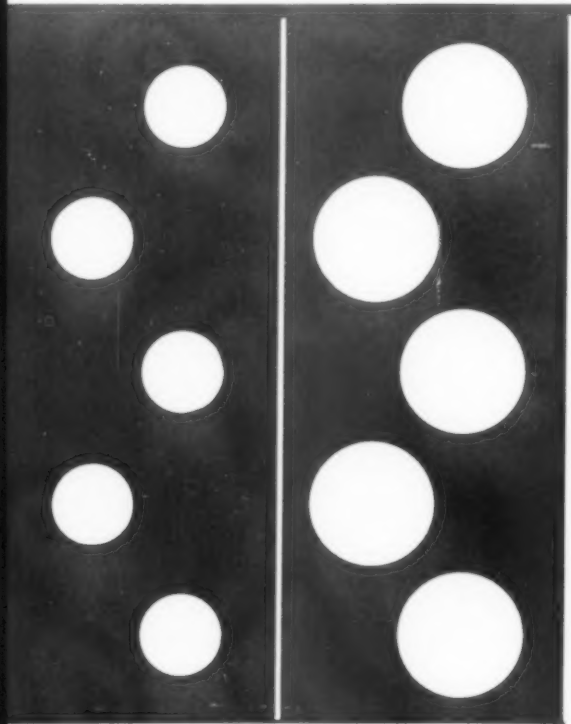
BIG HOLE PERFORATING

For Formation Treating

56% LARGER Diameter • 144% LARGER Opening

780 SUPER E BULLET



Comparison of area of standard perforations (above, left) and 780 Super E perforations (above, right).

You are looking at the actual size of perforations produced by Lane-Wells new 780 SUPER E BULLET Perforating. Compare these holes with the size of perforations produced by standard bullets—compare the hole size with even smaller holes by other types of perforating.

Designed especially to produce a large hole and maximum formation cracking, the 780 SUPER E BULLET really paves the way for hydraulic fracturing, explosive fracturing, acidizing, and other types of formation treatments. Because the 780 SUPER E BULLET is fired by a standard Lane-Wells Type E gun, you get all the advantages of selective firing and proved performance.

Ask your nearest Lane-Wells representative about this newest service by the company that originated perforating for the petroleum industry!

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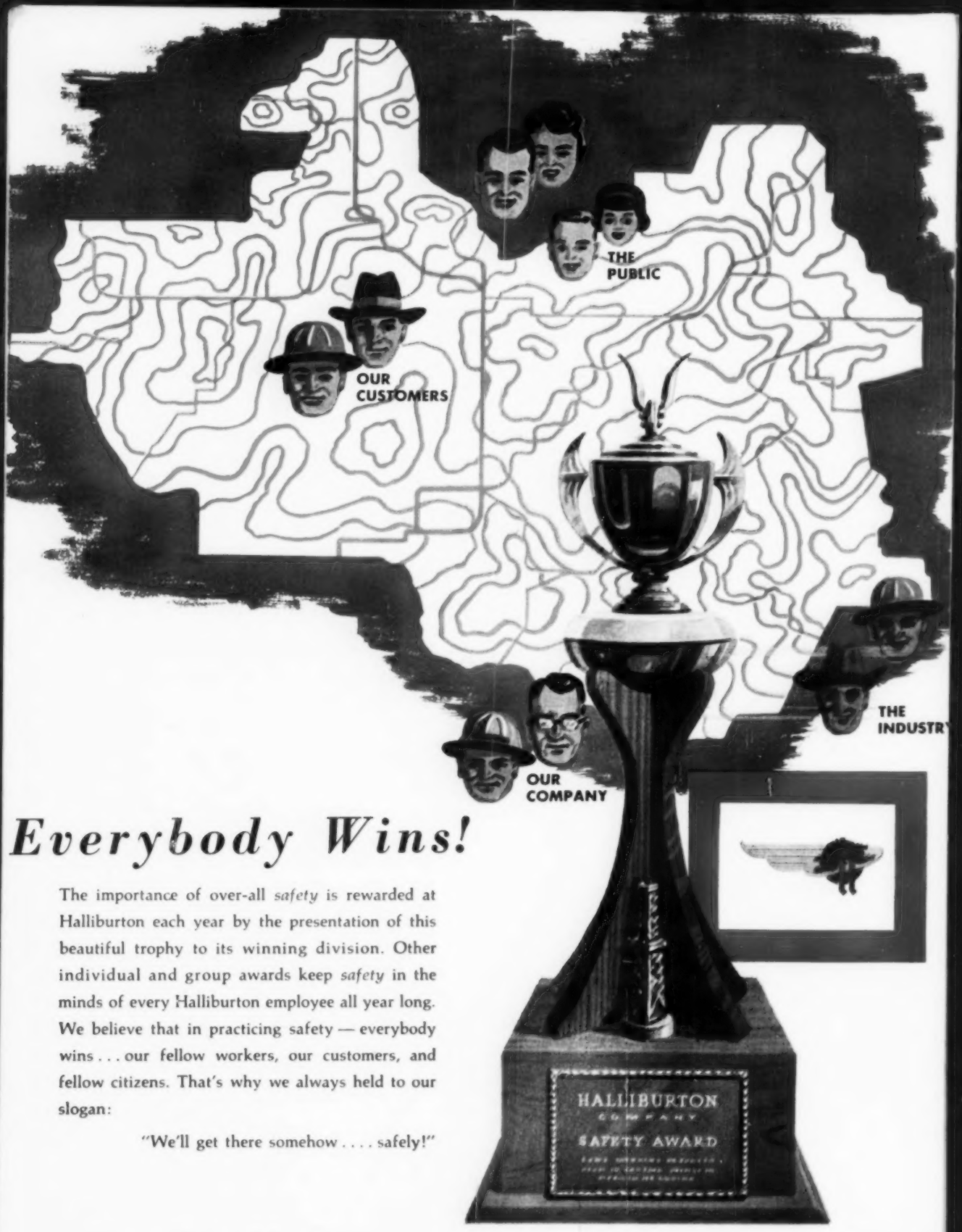

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The importance of over-all *safety* is rewarded at Halliburton each year by the presentation of this beautiful trophy to its winning division. Other individual and group awards keep *safety* in the minds of every Halliburton employee all year long. We believe that in practicing safety — everybody wins . . . our fellow workers, our customers, and fellow citizens. That's why we always held to our slogan:

"We'll get there somehow . . . . safely!"

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